unipan

instruction manual

HOMODYNE RECTIFIER
VOLTMETER
Type 202B

U N I P A N Scientific Instruments

Subsidiary of the Polish Academy of Science

Warszawa - POLAND

P.O.B. 225 Phone: 20-62-21

INSTRUCTION MANUAL

HOMODYNE RECTIFIER VOLTMETER Type 202B

SOLE EXPORTER: METRONEX

Warszawa - POLAND

C O N T E N T S

1. GENERAL

1.1. Application

1.2. Operating principle

2. TECHNICAL SPECIFICATION

3. DESCRIPTION

3.1. Circuitry

3.2. Construction

3.3. Accessory equipment

4. OPERATING INSTRUCTIONS

4.1. Preliminaries

4.2. Operation

4.3. Switching off

5. MAINTENANCE

5.1. Calibration check

5.2. Dismantling the instrument

5.3. Disassembling

5.4. Apparatus required for tests

5.5. Schedule of tests

5.5.1. Power Supply and 250V Regulator unit

5.5.2. The-150V Regulator

5.5.3. Input Attenuator

5.5.4. Phase Shifter

5.5.5. Homodyne Detector

5.5.6. Microammeter Circuit

5.5.7. Vacuum-tube Voltmeter

5.5.8. Clipper

6. COMPONENTS LIST

I L L U S T R A T I O N S

Fig. 1. Front Panel

Fig. 2. Block diagram

Fig. 3. Component location : Phase Shifter

Fig. 4. Component location : Homodyne Detector

Fig. 5. Component location : Vacuum Tube Voltmeter and - 150V Regulator

Fig. 6. Component location : Clipper

Fig. 7. Component location : Power Supply Unit

Fig. 8. Component location : Front Panel

Fig. 9. Circuit diagram : Phase Shifter

Fig.10. Circuit diagram : Homodyne Detector

Fig.11. Circuit diagram : Vacuum-Tube Voltmeter and - 150V Regulator

Fig.12. Circuit diagram : Clipper

Fig.13. Circuit diagram : Power Supply Unit

Table 1. Static voltage values

1. GENERAL

1.1. Application

The type 202B Homodyne Rectifier Voltmeter has been designed for the measurement of a.c. voltage in signals with heavy noise or interference background. Due to the use of homodyne /phase - sensitive/ detection the noise- or interference-level may exceed many times this of the test signal. The type 202B Homodyne Rectifier Voltmeter can be used in conjunction with wide- or narrow-band amplifiers; particularly suitable are the UNIPAN Selective Microvoltmeters 203, 207 and 208.

An inherent feature of homodyne detection is the need of a "reference signal", having the same frequency as the test signal. The reference signal for the type 202B Homodyne Rectifier Voltmeter should have an amplitude of at least 0.1 volt; its phase relation to the test signal and its wave-shape is of no importance. Any shape is allowed, if symmetrical in respect to zero level and the start line, i.e. sine, square, trapezium and triangle waves are suitable. In general the reference signal is derived from the generator which delivers the test signal into the apparatus-under-test.

The type 202B Homodyne Rectifier Voltmeter when operating in conjunction with a selective microvoltmeter /type 203, 207 and 208/ is suitable in physical or electronic research laboratories for the measurement of smallest L.F. signals, in laboratory set-ups for testing semiconductor materials and components, for photometric or spectrophotometric measurements. The latter application requires additional equipment.

When combined with a selective microvoltmeter /type 203, 207 or 208/ the Homodyne Rectifier Voltmeter is a very sensitive bridge balance indicator.

1.2. Operating principle

The exceptional performance of this instrument is mainly due to the homodyne detector delivering its output into the vacuum tube d.c. voltmeter.

The homodyne /i.e. phase-sensitive/ detection principle

is analogue to this of the commutator rectifier, changing-over the direction of the circuit current synchronously with the frequency of the input to-be-rectified.

When an alternating current is passed via the commutator rectifier input its contacts allow the positive half-wave to flow through the load; however, when the direction of the input current is opposite, the contacts change-over reversing the load connection. Thus, the current in the external output circuit of the rectifier flows always in one direction being thus rectified.

The synchronism of commutation frequency with the frequency of the current to-be-rectified is obligatory. Failure to meet this requirement gives raise for obtaining at the output alternating current, with frequency equal to the difference of input frequency and commutation frequency; the d.c. component is zero.

The condition for optimum commutator rectifying efficiency /ratio of the d.c. output component to the a.c. input amplitude/ lies in perfect conformity between the contact change-over /commutation/ and the moment when the input alternating wave passes the zero line. Or, the d.c. component at rectifier output will be maximum if the reversing of current flow takes place always when the input a.c. changes its polarity.

The greater the phase difference, the smaller will be the d.c. component. For a 90° phase difference and sine-wave supply /the change-over corresponds to maximum input current amplitude/, the d.c. component at the output is zero.

To generalize, the maximum efficiency of a commutator rectifier supplied with sine-wave corresponds to 0° or 180° phase shift while for 90° and 270° the efficiency is zero.

The operating principle of the phase-sensitive detector in the 202B Homodyne Rectifier Voltmeter is similar to this of the commutator rectifier except the change-over function which is not of mechanical character. This function is provided by an all-electronic circuit consisting of vacuum-tubes, semiconductor diodes and suitable R- and C- components. The "current flow change-over" is controlled externally by a "reference signal" which should be

synchronous with the test signal.
The task of the phase sensitive detector is to pick-out of a heavy noise and interference background the desired signal, synchronous with the reference signal, and translate it into d.c. output voltage.
As mentioned above, in commutator rectifiers as well as in phase-sensitive detectors only the synchronous component will produce d.c. at the rectifier output; all a.c. components having a frequency other than this of the reference signal will produce no d.c., just some ripple with differential frequency. The same applies to the noise; only the frequency spectrum will be shifted.
Odd test signal harmonics of higher order and odd subharmonics synchronized with the reference signal frequency can contribute to the d.c. detector output. However, the effect will be the smaller, the higher is the order of these harmonics; additional attenuation will be due to phase difference between the harmonics and the test signal alone.
A smoothing resistance-capacitance filter is inserted between the detector output and d.c. vacuum-tube voltmeter input for the reduction of ripple level. Furthermore, the filter provides facilities for significant limitation of the bandwidth.
The test signal is passed via a phase shifting network designed for phasing the test- and reference-signals, the control providing thus means for maximum sensitivity adjustment.
A two-way limiter circuit - clipper - is used for the shaping of the reference signal from any symmetrical waveform into a square wave with constant amplitude; thus the voltmeter readings are independent of the shape and amplitude of the reference signal.

2. TECHNICAL SPECIFICATION

2.1.	Frequency range	: from 1.5 c/s to 50 kc/s
2.2.	Selectivity /bandwidth/	: stepwise variable: 0.01 c/s, 0.1 c/s, 1 c/s, 10 c/s, 100 c/s /independent of the centre frequency/

2.3. Sensitivity ranges : 1, 3, 10, 100, 300 volts /-10 to +40 dB/ f.s.d

2.3.1. Accuracy : ± 3% 5 c/s to 5 kc/s, ± 5% below 5 c/s and abow 5 kc/s

2.3.2. Linearity : within 1% of f.s.d.

2.3.3. Input resistance : ca. 240 kohms

2.3.4. Minimum allowed signal-to-noise ratio : 1 : 10 /-20 dB/

2.4. Outputs :

2.4.1. balanced floating or earthened high-resistance output, source resistance ca. 2 x 4 kohm, output voltage ± 5 volts,

2.4.2. balanced recorder or external meter output, load resistance 2 kohm, available current 1 mA,

2.4.3. earthened recorder or external meter output, load resistance 1 kohm, available current 1 mA- polarity positive or negative.

2.5. Reference signal requirements : sine, square, trapezium or triangle wave

2.5.1. input : i/ 0.1 to 15 volts into 240 kohm
: ii/ 15 to 150 volts into 2.4. Mohm

2.5.2. reference voltage measurement accuracy : i/ ±5% /0.1 to 15 volts/
ii/ ±10% /15 to 150 volts/
/measurement of the voltage applied to the REF. VOLT. INPUT 15 - 150V/.

2.6. Accuracy of the total signal voltage measurement/ with noise/ : ± 10%

2.7. Phase shift adjustment	:	stepwise: 0^{o} or 180^{o}, continuously from 0^{o} to 180^{o} or from 180^{o} to 360^{o}
2.8. Power supply:		110 or 220 volts, ±5, ±10, ±20V; 50 c/s
2.8.1. Power consumption:		ca 100VA
2.9. Outer dimensions	:	500 x 220 x 300 mm /20 x 9 x 12 inches/
2.10. Weight	:	16,5 kg nett /37 lbs/

3. DESCRIPTION

3.1. Circuitry

The type 202B Homodyne Rectifier Voltmeter consists of the following circuits :

Phase Shifter	/3.1.1./
Clipper	/3.1.2./
Homodyne Detector	/3.1.3./
Voltmeter	/3.1.4./
Power Supply Unit and ± 250V Regulator	/3.1.5./
-150V Regulator	/3.1.6./

The block diagram /Fig.2/ shows the arrangement of these circuits.

For correct instrument operation a reference signal is to be applied to one of the two available input sockets marked REF. VOLT. INPUT /SK1, SK2 in Fig.1/. The waveform should be symmetrical in respect to zero level and the start line and have an amplitude fitting into one of the two available ranges: 0.1 to 15 volts or 15 to 150 volts. The "0.1 - 15V" socket SK1 is connected directly to the clipper input. The clipper circuit shapes the input wave into a square wave with amplitude being independent of the input level. The square signals at the clipper outputs /G and H in the block diagram/ are arranged to have identical shape and amplitude but opposite pola-

rity. These phase-split outputs are connected directly to the homodyne detector inputs /G and H in the block diagram/ The test signal is applied to the third detector input /E in the block diagram/ via the SIGNAL INPUT socket SK3, input attenuator and phase shifter.

For measurement the SIGNAL INPUT socket SK3 is connected to the input attenuator. For reference signal measurement the socket is left floating /switch SW5/. The reference signal from the "0.1 - 15V" socket is applied now to the attenuator input; other contacts of switch SW5 open the earth connection for resistor R31 which constitutes the lower arm of the reference voltage divider.

After being passed through the attenuator the test signal is applied to the A input of the phase shifter. At points B and D of this circuit /Fig.2/ the test signal phase is opposite but the amplitude is equal. The main phase shifting network is connected between these points. It consits of a group of capacitors selected by switch SW2 and a pair of series connected potentiometers for COARSE /RV5/ and FINE /RV4/ phase shift adjustment /For simplicity in Fig.2 only one potentiometer is shown/. Point C of this network is connected to the cathode follower control grids; the output is taken from the cathode of the follower, connected to point E. Switch SW2 making short point C with point B or D provides facilities for aperiodic 0^{o} or 180^{o} phase shifting; the resistance-capacitance phase shifting network is left disconnected in positions 0^{o} and 180^{o}.

The signals applied to the three homodyne detector inputs E, G and H are mixed together in the circuit: the E input signal is superposed /algebraically/ into the G input- and H input- signals. The function of G- and H- signals in the detector bridge is analogous with the change-over function in the commutator rectifier described above /see section 1.2. Operating Principle/.

Their instantaneous amplitude determines which of the bridge diodes should rectify the test signal. The rectified test signal is applied via a resistance-capacitance filter to the balanced vacuum-tube voltmeter input N1, N2. Switch SW4 provides time constant adjustment of the resistance-capacitance filter networks by selecting the in-circuit

capacity or by using the Miller capacity effect in a suitable condenser arrangement at the vacuum-tube voltmeter input. Other contacts of switch SW5, not shown in the block diagram Fig.2, reverse the voltmeter input connection from K-N1 and L-N2 into K-N2 and L-N1 when the polarity across the K-L terminals is changed due to a 180° phase change. Microammeter with series resistor and "+" "-" output terminals are connected to the balanced voltmeter output R-S. The terminals are designed for oscilloscope, external microammeter or external recorder connection. Constant load termination for the voltmeter output provides switch SW6 with associated resistors; the load may be balanced, floating or earthened, as well as of high or low resistance. The described circuits are fed by the mains transformer supplying suitable voltages to vacuum-tube heaters and H.T. rectifiers. The rectified H.T. is regulated to + 250 volts with return lead floating at - 150 volt level in respect to chassis. The latter voltage is held constant by a second regulator circuit.

The remaining part of these chapter deals with the details of the individual circuits of the 202B Homodyne Rectifier Voltmeter.

3.1.1. Phase Shifter /Fig.9/.

The phase shifting circuit consists of a cathode follower /V101a/ which separates the input attenuator /switch SW3 with associated resistors R18 .... R27/ from the amplifier input /V101b and V102a/. The task of the amplifier is to split the phase of the input signal. The obtained 180° out-of-phase signals are applied to the resistance-capacitance network providing facilities for selecting the required phase from the range 0° - 180°.

The contacts of switch SW2 enable the selection of condensers in the resistance-capacitance network, according to the signal frequency. The signal developed at the junction of capacitors C1 .... C5 with potentiometer RV4 controls the grid of the output cathode follower V102b. In the first two positions of switch SW2, marked 0° and 180° the cathode follower grid V102b is connected directly to the cathode of the first or of the second cathode-follower respectively,

providing facilities for stepwise phase shifting from 0^{o} to 180^{o} and vice-versa.
The total gain of the phase shifter /between the input A and output E/ amounts to 0,87. To improve stability triode amplifier stage has cathode-grid negative feedback. The amplifier is d.c. - coupled to provide good low frequency response.
The operating point of the V101a triode is adjusted by means of R102 to shift its cathode voltage to a level approximating control grid potential of the V101b triode.
Resistor R107 provides means for balancing the amplifier; increasing its value causes increase of a gain at the V102a cathode and vice-versa.

3.1.2. Clipper /Fig.12/

The task of the circuit is to shape the reference input signal if sine, trapezium or triangle into a square wave with constant amplitude, i.e. with amplitude independent of this of the input for input amplitudes meeting the requirements as outlined under Technical Specifications.
Square inputs may be used if with an unbalance not exceeding $\pm$ 0.5%; otherwise the reference square wave should be reshaped into trapezium by means of a suitable integrating network.
Additionally, a phase inverter is arranged to revert the output square wave phase; finally two balanced square waves are available at the G-and H outputs for driving the phase-sensitive detector.
The operation of the circuit is as follows: The input signal is passed via the V401a cathode follower to the control grid /p2/ of the V402 first triode. The V402 is arranged into a modified Schmitt's trigger circuit. Modification consists in using nonlinear coupling between the cathodes /diodes D401, D402, resistors R408, R409/ and in providing AC-coupling /C402, high capacitance/ from the first triode anode /p1/ to the second triode grid /p7/. The first triode bias is automatically controlled by a circuit responding to any unbalance in the square waveform.
Any bias change of the first triode caused by an input amplitude exceeding the corresponding sensitivity level will

produce an opposite change of the first triode cathode potential via the coupling: first triode anode to second triode grid and between the cathodes via the diodes. Thus, the circuit is switching quickly into the state with both stage gains reduced below unity. This condition is maintained until the threshold level will be passed again, causing a similar switching into a symmetric astable state. It is seen, that very high circuit gain corresponds to grid potentials within the thersholds while below-unity gains are established for signals outside this span. The trigger sensitivity is variable by means of RV401. The trigger followed by the V403 triode cathode follower, delivering the square wave to point G. The square wave unbalance detector, comprising diodes D403, D404 and resistors R418, R419 is supplied from a divider in the cathode circuit of the cathode follower. Here, the mean values are compared with the negative and positive peaks, producing an error signal at the junction of R418 and R419. The error signal is amplified by the V403 pentode to establish its anode potential at a level as required for biasing the trigger to produce a 1:2 waveform duty ratio.

The V403 pentode is used simmultaneously as capacitance multiplier in respect to C405, connected between its anode and control grid. The resistors R418, R419, R420 combined with the Miller capacitance compose a long time constant - low-pass filter. Resistor R404 with capacitor C401 are included to integrate the bias of the V402 trigger.

The time constants of the integrating networks in the clipper are rather long. To increase their charging speeds after switching mains on, a diode D405 and a potentiometer RV402 supplied from the voltage divider R424, R425, R426, R422 are included. With the anode of V403 pentode being at a potential lower than this of the anode of D405, the latter will conduct by-passing the pentode's anode resistance, reducing so the pentode gain and increasing the charging speed of C405.

During normal operation, the potential of the diode anode should be established ca. 1 volt below the pentode V405 anode to provide reverse polarization of D405 and thus to isolate the V403 pentode anode circuit from the voltage divider

The square wave inverter uses the V401b pentode. The stage gain is being kept at unity by the negative feedback loop R430, R431 between anode and the control grid. With inputs small, or with no input signal at all, the trigger may oscillate at a V.L.F, to maintain high sensitivity and to allow fast synchronization with any input having the minimum required amplitude.

3.1.3. Homodyne Detector /Fig.10/

The homodyne detector consists of two identical amplifiers employing double tubes ECF80 /V201 and V202/ and the main detector bridge with semi-conductor diodes D201, D202, D203 and D204. There are three inputs: E, G and H. The test signal is applied to input E, while G and H are supplied by the reference square-wave. The signal amplitude is superposed onto the square-wave across resistance networks connected between E - G and E - H. The two new established signals drive the V201 and V202 triode cathode followers coupled to assiociated pentodes by common cathode resistances. Thus, the main rectifier bridge is supplied with the test signal superposed on the square-wave, amplified by the pentode sections of V201 and V202. The operating principle of homodyne detection was already dealt with in section 1.2. The rectified signal is developed at the detector output terminals K-L. The square-wave voltages with correctly balanced bridge cancel at its output.
To compensate the bridge against diode characteristic variations and to stabilize the gain of the homodyne rectifier circuit a negative feedback is applied grids of the pentode sections.
Potentiometers RV201 and RV204 provide means for shifting the operating point of amplifiers V201 and V202.
Potentiometer RV202 provides test signal gain adjustment in both amplifiers by changing the amount of negative feedback. The adjustment does not change the gain for the square-wave signal.
Potentiometer RV203, adjusting the amount of negative feedback for one of the amplifiers is used for balancing the detector circuit at symmetrical square-wave signal supply at points G and H. The adjustment applies to the test signal

gain as well as to gain of the square-wave signal. Trimming capacitor C207 is for flattening the frequency response of the negative feedback channel.

3.1.4. Vacuum-tube D.C. Voltmeter /Fig.11/

The circuit of the d.c. vacuum-tube voltmeter is balanced through-out. The voltmeter inputs are connected to the detector output via resistance-capacitance filters /with stepwise variable capacitances/switch SW4/, which determine the homodyne detector selectivity/ and via switch SW5 reversing the polarity according to the phase-shift between the test and reference signals.
The first voltmeter stage is a differential cathode-coupled amplifier, V301. Its anodes are d.c.-coupled via resistance divider to the respective input grids of the output cathode followers arranged on double triode V302. The moving-coil d.c. meter /M1/ with an associated resistor system is connected across the cathodes of the output cathode followers; the resistor system with switch SW6 enables the external connection of output load /meter, recorder/ to terminals TL1, TL2, TL3; the load arrangement may be balanced, floating or earthened. The front panel potentiometer, RV6 /ZERO ADJ./ is provided for meter zero adjustment. The output potential of terminals TL1 and TL3 in respect to ground can be adjusted by means of the potentiometer RV2, at the front panel; the latter being also used in no-signal condition for bringing the potential to zero.

3.1.5. Power Supply Unit and 250V Regulator /Fig.13/

The unit consists of the mains transformer Tr501, two selenium rectifiers MR501 and MR502 and a H.T. regulator, employing V501, V502, V503 and V504 tubes.
The transformer primary comprises two identical 110 volt windings and an additional 5; 10 and 20 volt windings, providing correct transformer tapping for 110 volt ± /0, 5, 10 or 20/ volt or 220 volt ± /0, 5, 10, 20/ volt mains. The transformer primary circuit is protected by means of fuses FS501 and FS502 arranged so, that no rating change is required when changing-over from 220 volts to 110 volts

or vice-versa.
There are seven windings at the Tr501 secondary. Two of them supply the rectifiers MR501 and MR502, while the remaining deliver L.T. 6.3 volts with various current ratings for all valve heaters through-out the instrument. L.T. for the V301 in the vacuum tube voltmeter circuit is kept constant by means of the V505 barretter.
The rectified H.T. is derived from the series connected outputs of rectifiers MR501 and MR502 and smoothed by choke - capacitance filter consisting of an iron-cored choke and condensers C502, C501 and C503.
Initially smoothed H.T. is delivered directly to the anodes of the series tubes V501 and V502 and via resistors -R505, R507 to the their screen grids V502 and V501 which are connected in parallel are controlled from the output of the regulator d.c. amplifier employing a double-triode, V503. The error signal for the regulator is applied between the grid and the cathode of the amplifier /pin 2 and 3, respectively/. The error signal is establishod as a potential difference between a reference voltage derived from the voltage reference ion-discharge tube V504 /applied to grid, pin 2/ and a portion of the H.T. output /applied to cathode, pin 3/ tapped from the voltage divider R509, R511, R513, R514.
To improve ripple smoothing the cathode /pin 3/ of tube V503 is shunted by the electrolytic capacitor C500 to the "+" rail of the regulated H.T. output; the grid /pin 2/ and the cathode /pin 8/ of the second triode are shunted by condensers C506 and C504, respectively to the "-" rail of the regulated H.T. output. Further ripple smoothing is accomplished by condensers C507, C508 across the H.T. output.
An additional regulator circuit is fitted, comprising Zener diodes D501 and D502 and resistors R524, R525. The D502 anode is connected to the electronic regulator output to increase the regulated voltage at the D501 cathode.

3.1.6. The - 150V Regulator /Fig.11/

The circuit is mounted on a common chassis with the vacuum -tube voltmeter. It is used to maintain the return lead of

the +250 Volt H.T. at a potential of -150 volts in respect to earth. The circuit consists of a two-stage amplifier /double-triode V303/ and a variable resistance /constitued by the parallel connected triodes of V304/ inserted in series between the "+" rail and the earth. Interstage coupling consists of the resistance voltage dividers. The circuit compensates for current distribution changes from the H.T. "+" to earth and from earth to H.T. "-", maintaining at 150 volt the voltage drop across the components connected between the earth and the H.T. "-". The value of the regulated voltage is determined by the voltage divider R327, R318 and R330, delivering control voltage to the first amplifier stage.
The resistance-capacitance filter comprising C305 and R321 is designed to avoid H.F. parasitic oscillation.
Another resistance voltage divider consisting of R332, R333 and C303 maintains the heater circuit potential of the valves /which have their cathodes at a negative potential in respect to ground/ floating at an approximately mean level. The circuit protects the cathode-heater insulation, maintaining the cathode-heater voltage for the tubes V201, V202, V401, V402 and V403 below the maximum ratings.

3.2. Construction

The mounting frame of the instrument is composed of light--alloy parts and form-sections of bounded steel sheets. Although compact design and modern styling the arrangement provides fast access to all circuit components and easy mounting and demounting procedure. The cabinet consists of the top and bottom covers and removable rear-panel, fixed by six screws. Each of these parts has separate fixing. The cover fixing screws are accessible at the instrument bottom.

3.3. Accessory equipment

The instrument is delivered with the following equipment:

2 pcs. coaxial plugs type ZM-7/U.
2 pcs. spare fuse inserts type Bt-20/5-1A.
1 pc. Instruction Manual

1 pc. plastic instrument envelope.

4. OPERATING INSTRUCTION

4.1. Preliminaries

4.1.1. Before connecting the instrument to mains make sure that the mains selector switch /MVS 501, fig.13/ setting complies with the local mains voltage. When leaving the factory the instrument is connected for 220 volt supply.
If the connection at the mains tapping panel of the instrument does not comply with the local mains voltage, proceed as follows.

CAUTION ! Make sure that the mains plug terminating the instrument mains cable is disconnected from the mains socket.

4.1.1.1. Remove the cover panel at the instrument rear, clearing the fuses and the mains selector switch.

4.1.1.2. Adjust the two selector links to a value closest to the available mains voltage.

4.1.1.3. Replace the cover panel.

NOTE: When changing-over from 220 volt ± 20 volt to 110 volt ± 20 volt or vice-versa the fuse rating may remain unchanged.

4.1.2. Set control knobs as follows:

4.1.2.1. The mains switch /in the upper left-hand corner at the front panel/ - to OFF.

4.1.2.2. The OUTPUT switch /below the mains switch/
- to C.R.O. /cathode-ray-oscilloscope/ if a C.R.O. or other high-impedance-input instrument is required to be connected across the "+" "-" output terminals.
- to "+" or "-", if a 1 kohm meter or recorder is required to be connected across the "+" or "-" terminals, according to its polarity arrangement,
- to "±" for balanced supply /for 2 kohm load/.

4.1.2.3. METER SECTOR switch - to ZERO ADJ.

4.1.2.4. SELECTIVITY switch - to 1 c/s.

4.1.2.5. SENSITIVITY switch - to OFF.

4.1.2.6. PHASE SHIFT /FREQUENCY RANGE switch to 0^{o}.

4.1.2.7. PHASE SHIFT-COARSE/FINE potentiometers-whatever position.

4.1.2.8. RV1, and RV2, screw-driver adjustments - do not change their position.

4.1.2.9. Check meter zero.

4.2. Operation

4.2.1. Power may be switched on after having completed the procedure outlined in section 4.1. above; set the mains switch /upper left-hand corner of the front panel/ to ON.

4.2.2. The control lamp near the mains switch will light.

4.2.3. Approximately 30 seconds after switching on the meter pointer will indicate 2 - 3 scale divisions. Allow the instrument to warm-up for at least 15 minutes and adjust the control ZERO ADJ. until meter reads zero.

4.2.4. Apply the reference signal to one of the coaxial REF.VOLT INPUT sockets /lower lefthand corner of the front panel/ according to the voltage of the accessible reference source. Apply the signal to the "15 - 150" socket if the value of the voltage is unknown, but below the 150 volt limit.

4.2.5. Check and readjust meter zero, if necessary, and set the METER SELECTOR switch to OUTPUT 0^{o}. If there is a meter indication and/or the reading is not stable, change-over to socket "0.1 - 15V". The detector balance can be adjusted by means of potentiometer RV1 /upper right-hand corner of the instrument front panel. In view of the large time constants in somecoupling networks the adjustment should be changed slowly. Set the METER SELECTOR switch to OUTPUT 180^{o} to ensure that the zero adjustment is correct; with correct adjustment the meter reading should remain unchanged. The meter reading - if any - shows insufficient zero adjustment /4.2.3./ or absence of the reference signal /4.2.4., 4.2.5./.

4.2.6. With voltmeter zero adjusted /4.2.3./ and detector bridge balanced /4.2.5./, the main measurement can be commenced. Apply the test signal to SIGNAL INPUT socket, set the METER SELECTOR switch to INPUT VOLT /x10/. Change step-by--step the position of the SENSITIVITY switch beginning from OFF and watching the meter, until the reading is above one third of f.s.d. In this condition the meter indicates the value of the applied signal, and the instrument sensitivity is one-tenth of the value read at the SENSITIVITY switch position. Without changing the SENSITIVITY switch position change the METER SELECTOR to OUTPUT 0° or to OUTPUT 180° if the obtained deflection was leftwards from zero.

To provide correct reading set the FREQUENCY RANGE switch to the position corresponding to the test signal frequency and adjust the COARSE and FINE PHASE SHIFT controls to obtain maximum meter reading. Read the measurement result from meter scale and SENSITIVITY switch position.

NOTE 1 : If the meter indication is unstable, increase instrument selectivity by setting the SELECTIVITY control to 0.1 c/s or 0.01 c/s, as required.

NOTE 2 : A Zener diode protects the meter from overload /for both directions/; meter readings leftwards from zero are immaterial; only the rightward readings are true, from zero to f.s.d. The protecting circuit does not cover external devices connected to output terminals, thus reduce always their sensitivity when changing the switch positions of the instrument or when adjusting the phase shift.

NOTE 3 : The Homodyne Rectifier Voltmeter type 202B is designed for the measurement of signals with signal--to-noise ratio down to 1/10. Thus, never increase sensitivity above this SENSITIVITY switch setting at which the total input /main signal + noise/ was measured. The need of further sensitivity increase when measuring the main signal shows only that the signal-to-noise ratio is below 1/10, and the measurement at a more sensitive range will produce significant error. The need of redu-

oing the sensitivity shows that the signal-to-noise ratio is better.

4.2.7. For the measurement of the reference signal voltage switch the METER SELECTOR to REF.VOLT. /x 1, x 10/. Set the PHASE SHIFT/FREQUENCY RANGE switch to 0^{o} - if the reference signal frequency is within the range from 50 c/s to 5 kc/s - or into a position corresponding to its actual frequency, if it exceeds this range; for the latter case adjust the COARSE and FINE PHASE SHIFT controls to obtain maximum meter reading. The SENSITIVITY position should be selected according to the value of the reference signal voltage; the calibration is true for the "0.1 - 15V" input; when using the "15 - 150V" input multiply the reading by the factor of ten.

4.2.8. Potentiometer RV2 is for the no-signal adjustment of the potential at the "+" and "-" terminals of the instrument: /METER SELECTOR switch in position ZERO ADJ/.
This floating potential can be adjusted to the earth or an "approximately earth" level, the latter case providing zero backing-off for an external meter. With correctly adjusted voltmeter zero the potential of both terminals is shifted simultaneously.

4.2.9. The position of the SELECTIVITY switch should be always adjusted to a value at least 10 times below the test signal frequency, or in presence of hunting due to beating with an interference frequency, to a position for which the hunting is minimum.
Proper selection of instrument selectivity is the more important, the heavier is the noise and interference background.

4.2.10. The maximum anticlockwise position of the COARSE and FINE PHASE SHIFT controls corresponds to zero phase shift to the test signal. If the test signal frequency is at the upper limit of the range selected by the FREQUENCY RANGE switch, always commence the phase shift adjustment with the FINE control knob, covering the range from 0^{o} to 90^{o}; if, however, the test signal frequency is at the lower limit, and if it is required to obtain a phase shift

in the range from 90° to 180°, set the FINE control mid-traverse and adjust slowly the COARSE control to obtain maximum meter reading; to ensure that the adjustment is precise tune off the FINE control left and right noting that reading is always decreasing. All adjustments for the COARSE and FINE controls should be executed very slowly; it is particularly important when operating with narrow selectivity. This is also due to the fact that the phase shift adjustment is very steep from 0° to 100°, while rather moderate in the range from 100° to 180°. When the PHASE SHIFT / FREQUENCY RANGE switch is in 0° or 180° position, the COARSE and FINE controls are out of circuit.

4.2.11. The functions of the PHASE SHIFT / FREQUENCY RANGE switch change-over from 0° to 180°, and the change-over of the METER SELECTOR switch from OUTPUT 0° to OUTPUT 180° are different. The former causes the phase to change indeed, while the latter reverses only the polarity of the rectified detector output, as applied to the vacuum-tube voltmeter. However, inspite of different functioning the effect remain similar.

4.3. Switching off

Before switching the instrument power off:

4.3.1. Set the SENSITIVITY switch to OFF.

4.3.2. Set the METER SELECTOR switch to ZERO ADJ.

4.3.3. Switch mains OFF.

4.3.4. Remove the mains plug of the mains socket.

4.3.5. Replace the plastic instrument envelope.

5. MAINTENANCE

5.1. Calibration check.

Prepare the instrument for measurement proceeding as outlined in section 4.1.2.

Apply 1V /r.m.s/ ± 1%, 1 kc/s sine-wave to the "0.1 - 15V" REF.VOLT.INPUT /see 5.4. - Apparatus required for tests/.

Switch mains ON and proceed as in section 4.2.2., 4.2.3., 4.2.5., 4.2.7. adjusting the SENSITIVITY switch /SW3/ to

1V. If meter reading shows an error exceeding ± 3% of f.s.d. proceed as follows:

5.1.1. Switch mains OFF and disconnect the mains plug from power socket.

5.1.2. Dismantle the instrument /section 5.2. below/.

5.1.3. Switch mains ON and check the following supplies:
6.3. volt L.T. /heaters/
+ 100 volt H.T. /anodes/
- 150 volt H.T.
by means of a suitable multi-range tester and measure the ripple at the + 100 volt and - 150 volt suplies; for both cases the ripple voltage should not exceed 5mV peak-to--peak. During the measurement a 1 volt 1 kc/s reference signal should be applied to the 0.1 - 15 volt socket.
If the results differ from specified values, inspect the power supply & 250 volt regulator unit /item 5.5.1./ and the -150 volt regulator /item 5.5.2./

5.1.4. Test the performance of the phase shifter /item 5.5.4./

5.1.5. Test the performance of the homodyne detector /item 5.5.5/

5.1.6. Test the performance of the vacuum-tube voltmeter /item 5.5.7./

5.1.7. Test the performance of the clipper /item 5.5.8./

5.2. Dismantling the instrument

To gain access to the components and parts mounted inside the instrument it is necessary to remove the rear panel, and the separate top and bottom covers.
Before the removal of the rear panel remove the small panel fixed to it by two screws. It facilitates to pass the mains plug through the rear panel.
Undo the six fixing screws, located at the corners and in the middle of the longer edges, and remove the rear panel
Undo the four fixing screws, located at the instrument bottom and remove the bottom cover.
Undo the four top cover fixing screws, lift the cover out from its guides and remove carefully expanding externally its bottom edges, if required.

5.3. Disassembling

The individual instrument assemblies can be removed separately after opening their soldered connections with the remaining assemblies.
The power supply and 250 volt regulator unit is fixed by four screws to the two sections connecting the front and rear frames lower, at the L.H. side of the instrument. Further assemblies are fixed to the rear frame top and bottom transverse.

5.4. Apparatus required for tests.

The below listed instruments will be needed to follow the test procedures outlined in the next sections of this chapter

5.4.1. Multirange tester grade 1.5/2.5 for d.c. and a.c. voltage and current measurements with an internal resistance of at least 20 kohm per volt.

5.4.2. Sine-wave generator delivering 0 to 20 volts at 1 c/s to 50 kc/s.

5.4.3. C.R.O. with frequency response d.c. to at least 500 kc/s and sensitivity of at least 50 mV per cm.

5.4.4. Standard voltmeter, grade 1 providing measurements of a.c. voltages from 0 to 10 volts at 1 c/s to 50 kc/s.
The following apparatus will facilitate testing:

5.4.5. Variable transformer handling at least 200VA.

5.4.6. Vacuum tube voltmeter for 0 - 300 volt d.c.

5.4.7. A d.c. source, variable from 0.3 to 0.7 volts.

5.5. Schedule of tests.

5.5.1. Power Supply and 250V Regulator Unit /Fig.7, Fig.13/.
Connect the multirange tester set to 500 or 600 volts between the "-" rail of the power supply /"-" tester terminal/ and the anode of V501 or V502, i.e. pin 7 /"+" tester terminal/. The meter should read 320 to 400 volts; 350V is nominal at nominal mains voltage and nominal power supply load.

NOTE 1. The "-" rail of the power supply floats at -150 volts in respect to earth.

If the reading exceeds the stated limits, check the rectifier. The voltages across C501 and C502/1 should be similar and their sum should lie within 330 - 410 volts. Greate difference signifies the damage of one rectifier while too small sum to rectifier over-load.
The regulated voltage should maintain between 248 volt and 252 volt with all mains voltage values within ± 10% of the nominal.
If the voltage exceeds the said limits, measure the voltages at tube pins /Table 1/ and the ripple voltage at the output by means of a cathode ray oscilloscope; it should be below 5mV peak-to-peak.

5.5.2. The -150V Regulator.
Connect a d.c. voltmeter adjusted to 1.5V f.s.d. across resistor R.331. The voltage drop across the resistor should lie within the range of 0.25 to 0.75 volt.
If the voltage drop is out of these limits it signifies that the normal current distribution between the circuit supplied from "+100V" to earth and the circuits across "-150V" and earth is distorted; shunt R 305 to reduce the R 331 voltage drop, or alternatively, insert a series resistor between the -150V rail and earth to increase the R 331 voltage drop. If the potential of the -150V rail still fails to maintain at its nominal value measure electrode voltages at tube holders /Table 1/ and locate the fault.

5.5.3. Input Attenuator /switch SW3/. /Fig.8, Fig.9/.
Switch mains for the Homodyne Rectifier Voltmeter ON. Connect a vacuum-tube Voltmeter /GM 6012 Philips/ to cathode /pin 8/ of tube V101a. Connect the sine-wave generator set to 1 kc/s to the junction of resistor R25 with R26 and set the SENSITIVITY /SW3/ switch to 100V. Adjust generator output to read 3.16 volt on the voltmeter. Reset the switch SW3 to 30QV; the voltmeter should read 1 V.
If the error exceeds ± 0.5% proceed as follows:

5.5.3.1. Check /use a Wheatstone-bridge/ the value of R26 with

SW3 in position OFF, SW5 in any position except REF.VOLT. INPUT., socket SK3 open-circuit. The value of R26 should be 1.6 kohm ± 1%.

5.5.3.2. Select a value for R18 with which the voltmeter reading is 1 volt ± 0.5%. Apply the generator output to the junction of R24 and R25. Adjust generator output to 3.16 with SW3 in position 20V. Rest SW3 to 100V; the voltmeter should read 1 volt ± 0,5%. Select R19, if necessary.
Follow the same procedure for the remaining position of SW3 changing the generator connection and selecting the values for R20 and R21.

5.5.4. Phase Shifter /Fig.3, Fig.9/
Inspect the connections of switch SW2 and of associated components to points B, C and D. Switch mains ON. Apply to point A 1 volt at 1 kc/s. Connect the a.c. vacuum-tube voltmeter /GM 6012 Philips/ to point E.
Check d.c. voltages /Table 1/ using a d.c. vacuum-tube voltmeter.
The anode voltage of V101b /pin 6/ can be adjusted by means of resistor R102.
The gains of both stages /V101a and V102a/ should be equal To check the gain of V102a proceed as follows:

5.5.4.1. Set SW2 to 0^{o} and note the voltmeter /connected to E/ reading.

5.5.4.2. Set SW2 to 180^{o} and see if the reading remains unchanged. If the readings differ by more than ± 0.5% select the value of R107.
The total gain, i.e. the ratio of the a.c. voltage at point E to the a.c. voltage at point A should be at least 0.85; should the gain be lower reduce the value of R107; note, however, that if the d.c. voltages at pin 2 and pin 8 of V101 differ from each other, the change of R107 will change the anode potential of the pentode V101b /pin 6/; this may be compensated by altering R102.

5.5.5. Homodyne Detector /Fig.4, Fig.10/.
Check the d.c. voltages /vacuum-tube voltmeter/ at the individual vacuum-tube electrodes according to Table 1; the operating point of pentode V201 can be shifted by

means of potentiometer RV201, while this of the pentode V202 by means of RV204.
With a 1 volt, 1 kc/s sine-wave applied to the 0.1 - 15V /REF, VOLT. INPUT socket see at the C.R.O. screen, that the signals at points G and H are of equal amplitude but opposite phase.
No square-wave at G or H, or different amplitude signify a fault in the clipper circuit; check the clipper circuit /item 5.5.8/.
Connect the C.R.O. input to the junction of resistors R215 with R216, and next to the junction of R227 with R218 and see that at this points the square wave signals oppose each other and cancel. The adjustment is by RV1.
If the adjustment of RV1 gives no satisfying result, connect the C.R.O. input to point E and adjust RV1 to obtain minimum square-wave amplitude at E; having no sensitive C.R.O. remove the tube V102 in the phase shifter to eliminate the influence of the output resistance of the triode V102 cathode follower. Adjust potentiometer RV1 to obtain minimum square-wave amplitude at point E and reconnect the C.R.O. input to the junction of resistors R215 and R216, or R217 and 218; adjust RV203 to obtain complete cancelling of the square signal at the test points. Disconnect the C.R.O. and readjust potentiometer RV203 to obtain zero reading on meter M1 with METER SELECTOR switch /SW5/ set to 0^{o} or 180^{o}. If the adjustment of potentiometer RV203 gives no satisfying results check tubes V201 and V202, replace by new ones, if necessary, and repeat the above procedure.
Having completed the bridge balancing in respect to the square-wave signal set the METER SELECTOR switch to REF. VOLT. INPUT and apply 1 volt $\pm$ 1%, 1 kc/s sine-wave to the "0.1 - 15V" input to the instrument; the switch PHASE SHIFT FREQUENCY RANGE should be in position 0^{o}, and the SENSITIVITY switch in position 1V. D.c. voltages, as measured at the junction of R215 with R216 and R217 with R218 with a vacuum-tube voltmeter should amount to + 0.5 volt and - 0.5 volt respectively, while the meter M1 should read 1 volt.
The detector gain adjustment in respect to a.c. signals applied to point E can be achieved by means of potentiometer RV202, which is adjusted to obtain a 1 volt meter rea-

ding.
If the 1 volt reading can not be reached by adjusting the potentiometer RV202, check the microammeter circuit /item 5.5.6./ and the vacuum-tube voltmeter /item 5.5.7./.

5.5.6. Microammeter Circuit /Fig.8, Fig.11/.
The M1 meter should read 1 volt with 10 volts across the points R /+/ and S /-/. To check the microammeter outside the vacuum-tube voltmeter, disconnect the instrument mains supply, set SW6 /Fig.1/ to ± RECORDER and apply DC /ca. 13 volts/ to TL1 and TL3. Adjust the applied voltage to read 10 volts ± 1% across points R and S /connected to R1 and R6, respectively/. Select the value of R3 and R6 for the meter to read "1" exactly.

5.5.7. Vacuum-tube Voltmeter /Fig.5, Fig.11/.
Connect a d.c. voltmeter with at least 20 kohm per volt, set to 10 volts f.s.d. across TL1 /+/ and TL2.
Set the METER SELECTOR switch to ZERO ADJ., and the OUTPUT switch to RECORDER. Adjust the zero of meter M1 by means of the ZERO ADJ. control, and the zero of the connected voltmeter by means of the potentiometer RV2 increasing the voltmeter sensitivity gradually. Reconnect the voltmeter negative terminal to TL3 /-/ and set its range to 10 volts. Disconnect the soldered lead to N1 and apply -0,5 volt to this point. Meter M1 should read approximately 0.5 volts on its 0 - 1.0 scale.
The external voltmeter should read ten times more, i.e. approximately 5 volts. The Homodyne Rectifier Voltmeter output resistance at this condition is ca. 9 kohm, thus the external voltmeter reading has an error due to the ratio of the output resistance /9 kohm/ to voltmeter input resistance. See that potential of terminal TL1 /+/ in respect to ground is ca. +2,5V and this of the terminal TL3 /-/ ca. -2.5V. If the readings differ by more than 20% from the said values check vacuum-tubes and replace by new, if necessary. After replacement adjust balance by means of R301 or R303.

5.5.8. Clipper /Fig.6, Fig.12/.
Apply 1 volt, 1 kc/s sine-wave to input W; connect the C.R.O. input to point G or H. Note that the oscilloscope pattern is square, i.e. the "on" time should equal to the

"off" time.
The best procedure to check this condition is the following: synchronize the C.R.O. time base generator with an odd multiple of the displayed halfwave, to produce a combined display of two, 180°- shifted halfwaves. Vertical pulse edges covering each other indicate balanced waveform Vertical edges covering each other at intervals corresponding to fullwave only indicate rectangular wave. No edge coincidence indicates allways faulty time base synchronization.
With unbalance exceeding 1% check d.c. voltages at vacuum tube electrodes /Table 1/. Should these differ from those given in Table 1, check V403 and replace if necessary by a new one.
After having replaced the V403 it may be necessary to alter the value of R419 to restore square wave balance.
It should be born in mind when checking the clipper, that with a reference signal applied to input /W/ at a level being the threshold,, oscillation may be observed.
Clipper sensitivity is variable by means of RV401; sensitivity is increased by increasing or by decreasing the setting, according to the performance of V402.
Sensitivity should be tested at the lowest instrument frequency. After replacing a V402 see that the voltage at the RV402 moving contact is ca. 1 volt below the V403 anode potential; reset RV402 if required.
Mean potentials of the two clipper outputs: G and H should be equal. The mean potential of the H output is variable by means of R429.
Square wave amplitudes at the G-and H outputs should be equal, too. The amplitude at H is adjusted by means of R431.
The values of R429 and R431 affect each other. The selection should be made simmultaneously, watching the mean d.c, potential and the square wave amplitude at the H output.

6. COMPONENTS LIST

Circuit reference	Component				Specification		Manufacturer
1	2				3		4
	Resistors						
R1	OWS-212-0,5W	27k	±5%	-II	RN-57/MPM-14008		Telpod
R2	OWS-212-0,5W	47k	±5%	-II	"	"	"
R3*	" " "	6,8k	"	"	"	"	"
R6	" " "	5,1k	"	"	"	"	"
R7	" " "	5,1k	±1%	- I	WT-58/D-16050		"
R8	" " "	3,9k	±1%	- I	"	"	"
R9	" " "	1k	±1%	- I	"	"	"
R10	" " "	100ohm	"	"	"	"	"
R11	" " "	1k	"	"	"	"	"
R12	" " "	100ohm	"	"	"	"	"
R13	" " "	3,9k	"	"	"	"	"
R14	" " "	5,1k	"	"	"	"	"
R15	" " "	3,9M	±5%	-II	RN-57/MPM-14008		"
R16	" " "	560k	"	"	"	"	"
R17	" " "	24k	"	"	"	"	"
R18*	" " "	56k	"	"	"	"	"
R19*	" " "	51k	"	"	"	"	"
R20*	" " "	510k	"	"	"	"	"
R21	" " "	10k	"	"	"	"	"
R22	OWS-411- 2W	150k	"	"	"	"	"
R23	OWS-311- 1W	56k	"	"	"	"	"
R24	OWS-212-0,5W	16k	±1%	- I	WT-58/D-16050		"
R25	" " "	5,6k	±5%	-II	RN-57/MPM-14008		"
R26	" " "	1,6k	±1%	- I	WT-58/D-16050		"
R27	" " "	750ohm	±5%	-II	RN-57/MPM-14008		"
R28	" " "	470k	"	"	"	"	"
R29	" " "	47k	"	"	"	"	"
R30	" " "	750k	"	"	"	"	"
R31	OWS-411- 2W	240k	"	"	"	"	"
R32*	OWS-212-0,5W	4,3M	"	"	"	"	"
R33*	" " "	470k	"	"	"	"	"
R34	" " "	1k	"	"	"	"	"
R101	OWS-212-0,5W	1M	"	"	"	"	"
R102*	" " "	300ohm	"	"	"	"	"
R103	OWS-311- 1W	39k	"	"	"	"	"
R104	" " "	39k	"	"	"	"	"
R105	OWS-212-0,5W	62k	±1%	- I	WT-58/D-16050		"
R106	OWS-311- 1W	16k	±5%	-II	RN-57/MPM-14008		"
R107	OWS-212-0,5W	12k	"	"	"	"	"
R108	" " "	62k	±1%	- I	WT-58/D-16050		"
R109	" " "	82k	±5%	-II	RN-57/MPM-14008		"
R110	" " "	220k	"	"	"	"	"
R111	" 311 1W	39k	"	"	"	"	"
R112	" " "	39k	"	"	"	"	"
R113	" 212-0,5W	1M	"	"	"	"	"
R114	" " "	560ohm	"	"	"	"	"
R115	OWS-311- 1W	62k	"	"	"	"	"

1	2			3		4
R116	OWS-311- 1W	62k	±5% -II	RN-57/MPM-14008		Telpod
R117	OWS-122-0,1W	1k	±10%	ZN-58/MPM-14-06030		"
R118	" " "	100ohm	±10%	"	"	"
R119	" " "	100ohm	±10%	"	"	"
R201	OWS-212-0,5W-	47k	±5% -II	RN-57/MPM-14008		"
R202	" " "	13k	" "	"	"	"
R203	OWS-311- 1W-	91k	" "	"	"	"
R204	OWS-212-0,5W-	150ohm	" "	"	"	"
R205	" " "	36k	" "	"	"	"
R206	" " "	1M	" "	"	"	"
R207	" " "	100ohm	" "	"	"	"
R208	OWS-411- 2W-	6,2k	" "	"	"	"
R209	OWS-311- 1W-	18k	" "	"	"	"
R210	OWS-212-0,5W-	1M	" "	"	"	"
R211	" " "	30k	±1% - I	WT-58/D-16050		"
R212	" " "	30k	" "	"	"	"
R213	" " "	30k	" "	"	"	"
R214	" " "	30k	" "	"	"	"
R215	" " "	91k	" "	"	"	"
R216	" " "	91k	" "	"	"	"
R217	" " "	91k	" "	"	"	"
R218	" " "	91k	" "	"	"	"
R219	" " "	1k	±5% -II	RN-57/MPM-14008		"
R220	" "	1k	" "	"	"	"
R221	" " "	10k	" "	"	"	"
R222	" " "	10k	" "	"	"	"
R223	" " "	1M	" "	"	"	"
R224	OWS-311- 1W-	18k	" "	"	"	"
R225	OWS-411- 2W-	6,2k	" "	"	"	"
R226	OWS-212-0,5W-	100ohm	" "	"	"	"
R227	" " "	150ohm	" "	"	"	"
R228	OWS-311- 1W-	91k	" "	"	"	"
R229	OWS-212-0,5W	1M	" "	"	"	"
R230	" " "	36k	" "	"	"	"
R231	" " "	47k	" "	"	"	"
R232	" " "	13k	" "	"	"	"
R233	" " "	750k	" "	"	"	"
R234	" " "	750k	" "	"	"	"
R235	" " "	2,7k	" "	"	"	"
R301*	OWS-212-0,5W-	2k	" "	"	"	"
R302	OWS-311- 1W-	33k	" "	"	"	"
R303	OWS-212-0,5W-	2k	" "	"	"	"
R304	OWS-311- 1W-	33k	" "	"	"	"
R305	" " "	47k	" "	"	"	"
R306	OWS-212-0,5W-	150ohm	" "	"	"	"
R308	OWS-311- 1W-	39k	" "	"	"	"
R309	" " "	22k	" "	"	"	"
R310	OWS-212-0,5W	330k	" "	"	"	"
R311	" " "	910k	" "	"	"	"
R312	" " "	330k	" "	"	"	"
R313	OWS-212-0,5W	910k	" "	"	"	"
R314	OWS-411- 2W	20k	" "	"	"	"
R316	" " "	20k	" "	"	"	"
R318	" " "	680k	" "	"	"	"

1	2				3		4
R319	OWS-212-0,5W	220k	±5%	-II	RN-57/MPM-14008		Telpod
R320	" " "	150k	"	"	"	"	"
R321	" " "	1k	"	"	"	"	"
R322	" " "	200k	"	"	"	"	"
R323	" " "	1M	"	"	"	"	"
R324	" " "	330k	"	"	"	"	"
R325	" " "	910k	"	"	"	"	"
R327	OWS-311- 1W-	470k	"	"	"	"	"
R328*	OWS-212-0,5W	33k	"	"	"	"	"
R330*	" " "	47k	"	"	"	"	"
R331	" " "	27ohm	"	"	"	"	"
R332	" " "	24k	"	"	"	"	"
R333	" " "	47k	"	"	"	"	"
R401	" " "	1M	"	"	"	"	"
R402	" " "	820ohm	"	"	"	"	"
R403	OWS-411- 2W	30k	"	"	"	"	"
R404	OWS-212-0,5W-	1M	"	"	"	"	"
R405	OWS-122-0,1W-100ohm		±10%	-II	ZN-58/MPM-14-06030		"
R406	OWS-212-0,5W-680ohm		±5%	-II	RN-57/MPM-14008		"
R407	OWS-311- 1W-	12k	"	"	"	"	"
R408	OWS-212-0,5W-	2,7k	"	"	"	"	"
R409	OWS-311- 1W-	47k	"	"	"	"	"
R410	" " "	12k	"	"	"	"	"
R411	" " "	12k	"	"	"	"	"
R412	OWS-122-0,1W-100ohm		±10%	"	ZN-58/MPM-14-06030		"
R413	OWS-122-0,1W-100ohm		±10%	"	"	"	"
R414	OWS-212-0,5W-	1M	±5%	-II	RN-57/MPM-14008		"
R415	" " "	1M	"	"	"	"	"
R416	OWS-311- 1W-	20k	"	"	"	"	"
R417	" " "	20k	"	"	"	"	"
R418	OWS-212-0,5W-	1M	"	"	"	"	"
R419	" " "	910k	"	"	"	"	"
R420*	" " "	220k	"	"	"	"	"
R421	OWS-122-0,1W-100ohm		±10%	"	ZN-58/MPM-14-06030		"
R422	OWS-212-0,5W-390ohm		±5%	-II	RN-57/MPM-14008		"
R423	" " "	200k	"	"	"	"	"
R424	OWS-311- 1W-	39k	"	"	"	"	"
R425	OWS-212-0,5W-	5,1k	"	"	"	"	"
R426	" " "	12k	"	"	"	"	"
R427	" " "	470k	"	"	"	"	"
R428	" " "	510k	"	"	"	"	"
R429*	" " "	160k	"	"	"	"	"
R430	" " "	510k	"	"	"	"	"
R431*	" " "	24k	"	"	"	"	"
R432	OWS-122-0,1W-100ohm		±10%		ZN-58/MPM-14-06030		"
R433	OWS-311- 1W-	9,1k	±5%	-II	RN-57/MPM-14008		"
R434	OWS-212-0,5W-	1k	"	"	"	"	"
R435	OWS-122-0,1W-100ohm		±10%		ZN-58/MPM-14-06030		"
R501	OWS-311- 1W-	100k	±5%	-II	RN-57/MPM-14008		"
R502	" " "	100k	"	"	"	"	"
R503	" " "	100k	"	"	"	"	"
R504	" " "	100k	"	"	"	"	"
R505	OWS-212-0,5W-	1k	"	"	"	"	"
R506	OWS-211-0,25W-47ohm		"	"	"	"	"

1	2			3	4
R507	OWS-212-0,5W-	1k	±5% -II	RN-57/MPM-14008	Telpod
R508	OWS-211-0,25W	47ohm	" "	" "	"
R509	OWS-411- 2W-	27k	" "	" "	"
R511	OWS-212-0,5W-	6,8k	" "	" "	"
R512	OWS-212-0,5W-	5,1k	" "	" "	"
R514*	" " "	22k	" "	" "	"
R516	" " "	470k	" "	" "	"
R517	" " "	470k	" "	" "	"
R518	" " "	51k	" "	" "	"
R519	OWS-311- 1W-	100k	" "	" "	"
R520	OWS-411- 2W-	27k	" "	" "	"
R521	OWS-122-0,1W-	1,5k	±10%	ZN-57/MPM-14-06030	"
R522	" " "	1,5k	±10%	" "	"
R523	OWS-311- 1W	91ohm	±5% -II	RN-57/MPM-14008	"
R524	" 411- 2W	2,7k	" "	" "	"
R525	" " "	2,7k	" "	" "	"
R526	" 311-1W	91ohm	" "	" "	"

Variable resistors

RV1	2kohm 1W, wire-wound	Type 354	Vitrohm
RV2	10kohm 1W, wire-wound	Type 354	"
RV4	SP-Ib-5M-A-2W shaft 25P3	GOST-5574-50	Telpod
RV5	SP-Ib-50k-A-2W shaft 25P3	GOST-5574-50	Telpod
RV6	500ohm 1W, wire-wound	Type 354	Vitrohm
RV201	500ohm 1W " "	" "	"
RV202	5k 1W " "	" "	"
RV203	2k 1W " "	" "	"
RV204	500ohm 1W " "	" "	"
RV401	500ohm 1W " "	ser.112	Infin
RV402	5k " "	ser.112	Infin

Capacitors

C1	MPHP-2-160-A-1-II	WT-59/E-16161	Telpod
C2	MPHP-2-600-A-0,1-II	" "	"
C3	KBG-J-600-0,01-II	GOST-6118-52	"
C4	KBG-J-200-1000-II	" "	"
C5	KBG-J-200-1000-II	" "	"
C6	KBG-J-200-0,02-II	" "	"
C7	KBG-J-200-0,02-II	" "	"
C8	MPHP-3-160-A-2-II	WT-59/E-16161	"
C9	MPHP-3-160-A-2-II	" "	"
C10	KEK-20/250	RN-60/MPC-14036	Elwa
C11	Air trimmer TP30 3-30pF		Piesz. F-ka Zeg
C101	KBG-M2-400-0,1-II	GOST-6118-52	Telpod
C103	Ceramic trimmer, tubular TCR-3-N750-2-12-350-657	IEC 6.5.7.	Cerad
C104	KBG-J-200-0,1-II	GOST-6118-52	Telpod
C201	MPHP-1-200-A-10-II	WT-59/E-16161	"
C202	MMF-2,2 µ ± 10%-160V		Microfarad
C203	MPHP-2-160-A-1-II	WT-59/E-16161	Telpod

1	2	3	4
C204	MMF-2,2 µ ±10%-160V		Microfarad
C205	MPHP-2-160-A-1-II	WT-59/E-16161	Microfarad
C206	MPHP-1-200-A-10-II	" "	Telpod
C207	Air trimmer TP30 3-30pF		Piesz.F-ka Zeg.
C301	KSO-2-500-B-2000-II	GOST-6119-54	Miflex
C302	KSO-2-500-B-2000-II	" "	Miflex
C303	KBG-M2-400-0,1-II	GOST-6118-52	Telpod
C304	KEK-10/25	RN-60/MPC-14036	Elwa
C305	KCR-N750-33-5-500-656	WT-61/L5-019	Cerad
C306	KBG-J-200-0,1-II	GOST-6118-52	Telpod
C400	MPHP-3-400-A-0,25-II	WT-59/E-16161	Telpod
C401	MMF-2,2 µ ±10%-160V		Microfarad
C402	" " " "		"
C403	" " " "		"
C404	" " " "		"
C405	MMF-1 µ ±10% -160V		"
C501	KEN-50/350	RN-60/MPC-14036	Elwa
C502	KEN-50+50/350	" "	Elwa
C503	KEN-50/350	" "	Elwa
C504	KBG-J-600-1000-II	GOST-6118-52	Telpod
C505	KEK-10/350	RN-60/MPC-14036	Elwa
C506	KBG-J-200-0,1-II	GOST-6118-52	Telpod
C507	KEN-20+20/350	RN-60/MPC-14036	Elwa
C508	KBG-M2-400-0,25-II	GOST-6118-52	Telpod
	Semiconductor diodes		
D1	Zener diode OAZ 205		Philips
D2	Germanium diode SFD 108		Mistral
D201	Germanium diode SFD 108		Mistral
D202	Germanium diode SFD 108		"
D203	Germanium diode SFD 108		"
D204	Germanium diode SFD 108		"
D401	Germanium diode SFD 108		"
D402	Germanium diode SFD 108		"
D403	Silicone diode OA202		Philips
D404	Silicone diode OA202		"
D405	Silicone diode OA202		"
D501	Zener diode OAZ 207		"
D502	Zener diode OAZ 207		"
MR501	Selenium rectifier SPS-6B-250-100	WT-58/E-16110	Telpod
MR502	Selenium rectifier SPS-6B-250-100	WT-58/E-16110	Telpod
	Vacuum-tubes		
V101	E88CC		Philips
V102	E88CC		"
V201	ECF80		"
V202	ECF80		"
V301	E88CC		"
V302	E88CC		"
V303	ECC83		"
V304	ECC82		"
V401	ECF80		"

1	2	3	4
V402	E88CC		Philips
V403	ECF80		"
V501	EL86		
V502	EL86		
V503	ECC83		
V504	Jon-discharge reference tube 85A2		Philips
V505	Barreter 0,425-B-5,5-12		ZSRR
L501	Choke DFZB	WT-D-4245-0005	Zatra
M1	Microammeter MEA-1;0-100 µA	Nr cat.242526	Lumel
L1	Control lamp 6,3V/0,3A		Polam
	Switches		
SW1	BS2-MA		Torotex
SW2	12-EXV-S3, 7x1, rotary		"
SW3	12-EXV-S1 7x1, rotary		"
SW4	12-EXV-S2 5x2, rotary		"
SW5	12-EXV-S2 5x2 rotary		"
SW6	12-EXV-S1 4x2, rotary		"
	Coaxial sockets		
SK1	Coaxial socket UC1-G1		Eltra
SK2	" " UC1-G1		"
SK3	" " UC1-G1		"
TL1	Laboratory terminal PE-011		UNIPAN
TL2	" " "		"
TL3	" " "		"
Tr501	Mains transformer	202B.01	"
MVS 501	Mains voltage selector	Nr cat.279001	Mc Murdo
FS501	Fuse Btr-20/5-1A		
FS502	Fuse Btr-20/5-1A		

T A B L E 1

Static voltage values

Tube \ Pin	1	2	3	4	5	6	7	8	9
V101	55	-1,2	×	6,3V~ 0V=		100	×	-2	×
V102	100	-4	-2	6,3V~ 0V=		100	-2,5	0	×
V201	-0,7	×	×	6,3V~ -50V=		25	-75	-75	×
V202	-0,7	×	×	6,3V~ -50V=		25	-75	-75	×
V301	52	×	1,2	6,3V~ 0V=		52	×	1,2	×
V302	100	×	0	6,3V~ 0V=		100	×	0	×
V303	50	×	×	6,3V~ 0V= →n.9		28	-0,5	×	←n.4-5
V304	99,5	-2	×	6,3V~ 0V= →n.9		99,5	-2	×	←n.4-5
V401	100	×	98	6,3V~ -50V=		50	×	0	×
V402	-6	×	-74	6,3V~ -50V=		47	×	-74	×
V403	118	×	-110	6,3V~ -50V=		-77	-147	50	×
V501	×	96	102	6,3V~ 100V=		×	200	×	198
V502	×	96	102	6,3V~ 100V=		×	200	×	198
V503	-80	-120	-120	6,3V~ -120V= →n.9		96	×	-75	←n.4-5
V504	×	-150	×	×	-65	×	×	×	×
V505	×	5,5 ÷ 8,5V~						×	×

Remarks:

1. D.C. voltages were measured by a vacuum-tube voltmeter with 10 Mohm input resistance.
2. All voltages in respect to chassis

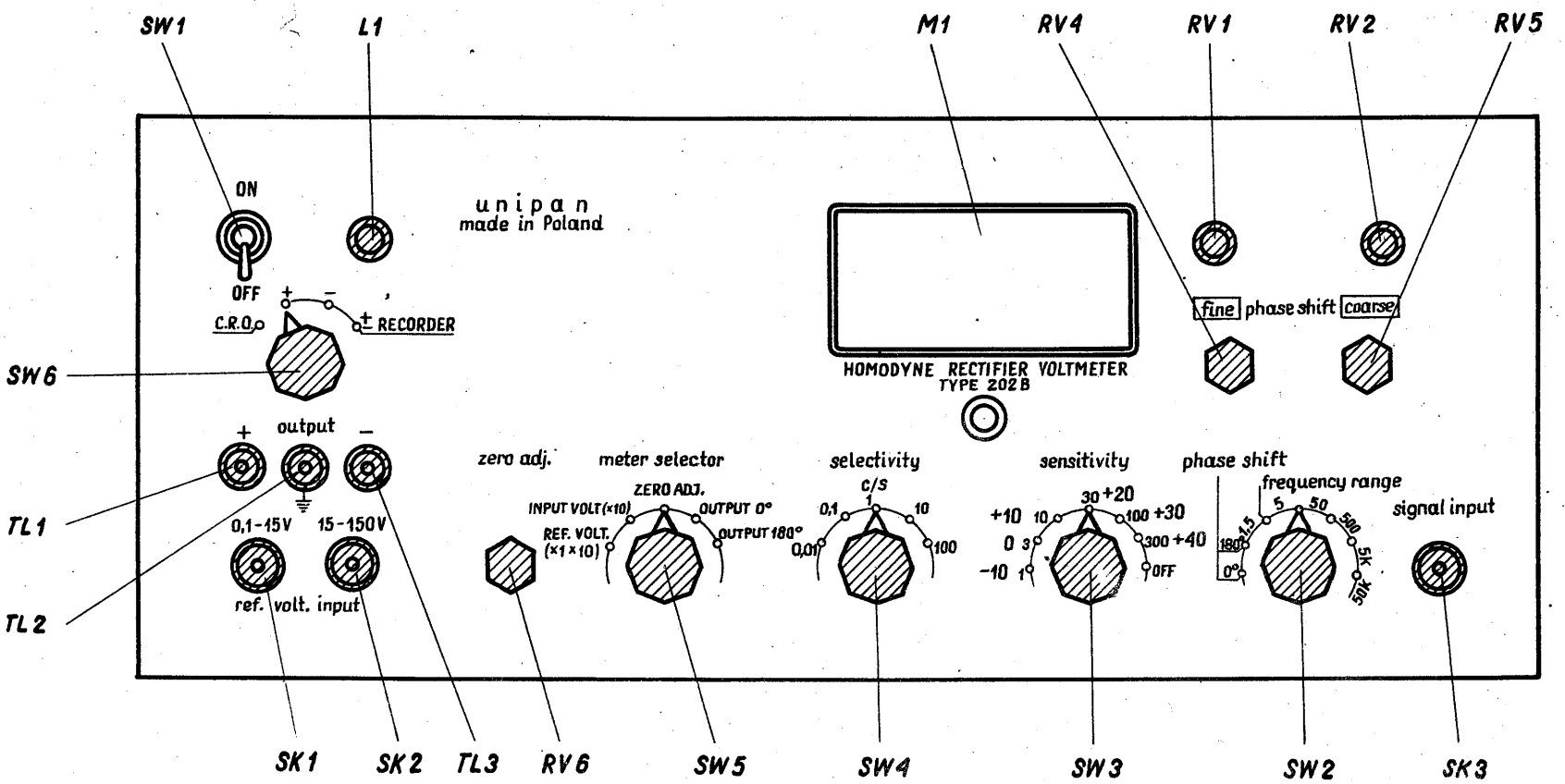

SW1
L1
M1
RV4
RV1
RV2
RV5
ON
OFF
C.R.O.
± RECORDER
unipan
made in Poland
HOMODYNE RECTIFIER VOLTMETER
TYPE 202B
fine
phase shift
coarse
SW6
+
output
−
TL1
TL2
0,1-15V
15-150V
ref. volt. input
zero adj.
meter selector
ZERO ADJ.
INPUT VOLT(×10)
OUTPUT 0°
REF. VOLT. (×1×10)
OUTPUT 180°
selectivity
c/s
0,1
1
10
0,01
100
sensitivity
30
+20
+10
10
100
+30
0
3
300
+40
-10
1
OFF
phase shift
frequency range
5
50
500
5K
50K
1,5
180°
0°
signal input
SK1
SK2
TL3
RV6
SW5
SW4
SW3
SW2
SK3

Fig.1.

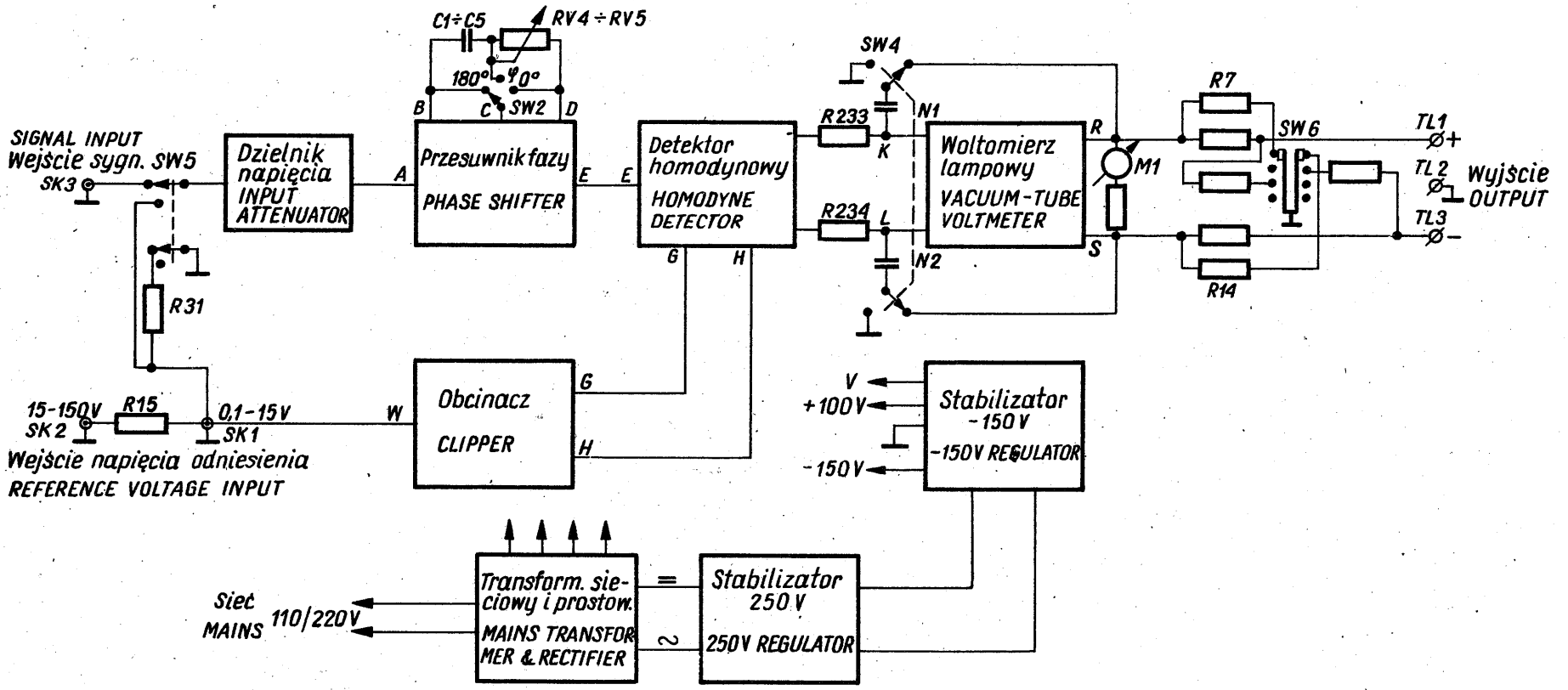

C1÷C5
RV4÷RV5
180°
90°
B
C
SW2
D
SW4
SIGNAL INPUT
Wejście sygn. SW5
SK3
Dzielnik napięcia
INPUT ATTENUATOR
A
Przesuwnik fazy
PHASE SHIFTER
E
E
Detektor homodynowy
HOMODYNE DETECTOR
R233
N1
K
R234
L
N2
Woltomierz lampowy
VACUUM-TUBE VOLTMETER
R
M1
S
R7
SW6
TL1
TL2
TL3
Wyjście
OUTPUT
R14
R31
15-150V
R15
SK2
0,1-15V
SK1
Wejście napięcia odniesienia
REFERENCE VOLTAGE INPUT
W
Obcinacz
CLIPPER
G
H
G
H
V
+100V
-150V
Stabilizator
-150V
-150V REGULATOR
Sieć
MAINS 110/220V
Transform. sieciowy i prostow.
MAINS TRANSFORMER & RECTIFIER
=
~
Stabilizator
250V
250V REGULATOR

Fig.2.

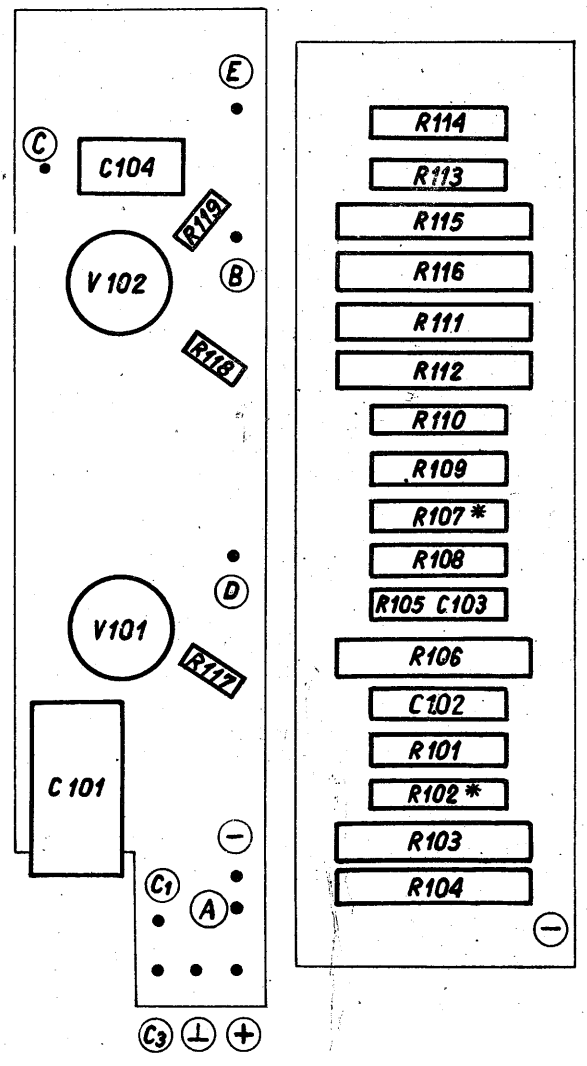

E
C
C104
R119
V102
B
R118
D
V101
R117
C 101
C1
A
C3
R114
R113
R115
R116
R111
R112
R110
R109
R107 *
R108
R105 C103
R106
C102
R101
R102 *
R103
R104

Fig.3.

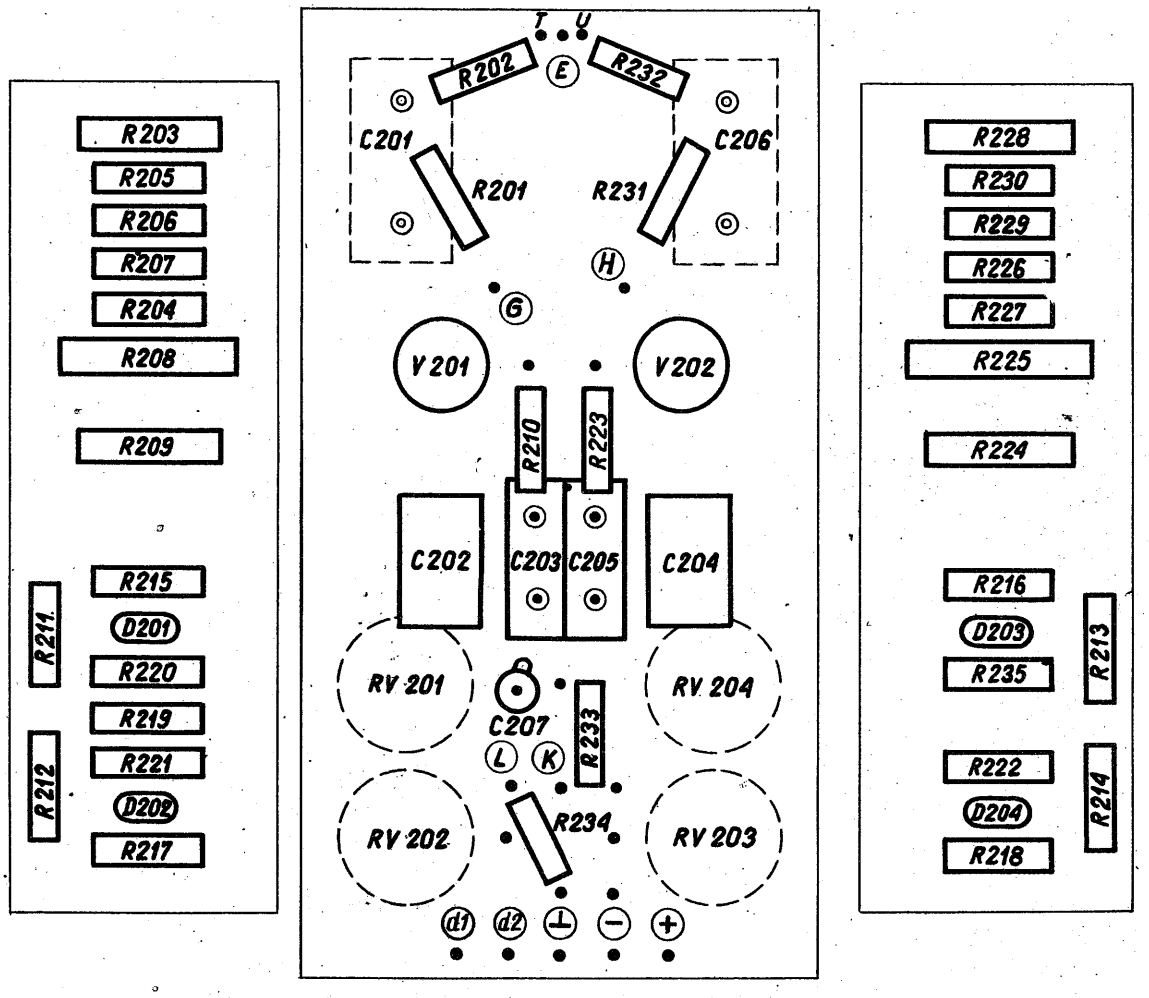

T
U
R202
E
R232
C201
C206
R201
R231
H
G
V 201
V 202
R210
R223
C202
C203
C205
C204
RV 201
RV 204
C207
L
K
R233
R234
RV 202
RV 203
d1
d2
R203
R205
R206
R207
R204
R208
R209
R211
R215
D201
R220
R219
R221
R212
D202
R217
R228
R230
R229
R226
R227
R225
R224
R216
D203
R235
R213
R222
D204
R218
R214

Fig.4.

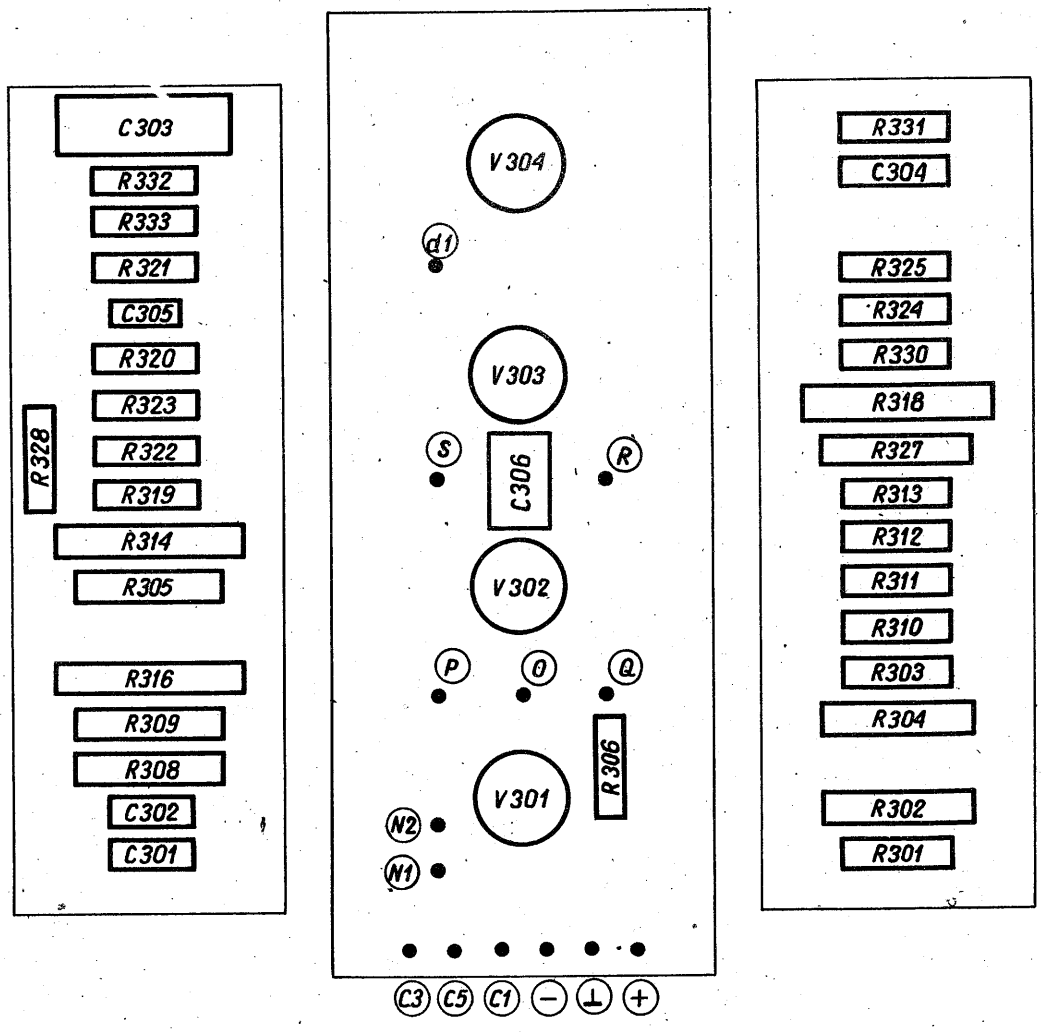

C303
R332
R333
R321
C305
R320
R323
R322
R319
R328
R314
R305
R316
R309
R308
C302
C301
V304
d1
V303
S
C306
R
V302
P
O
Q
R306
V301
N2
N1
C3
C5
C1
−
⊥
+
R331
C304
R325
R324
R330
R318
R327
R313
R312
R311
R310
R303
R304
R302
R301

Fig.5.

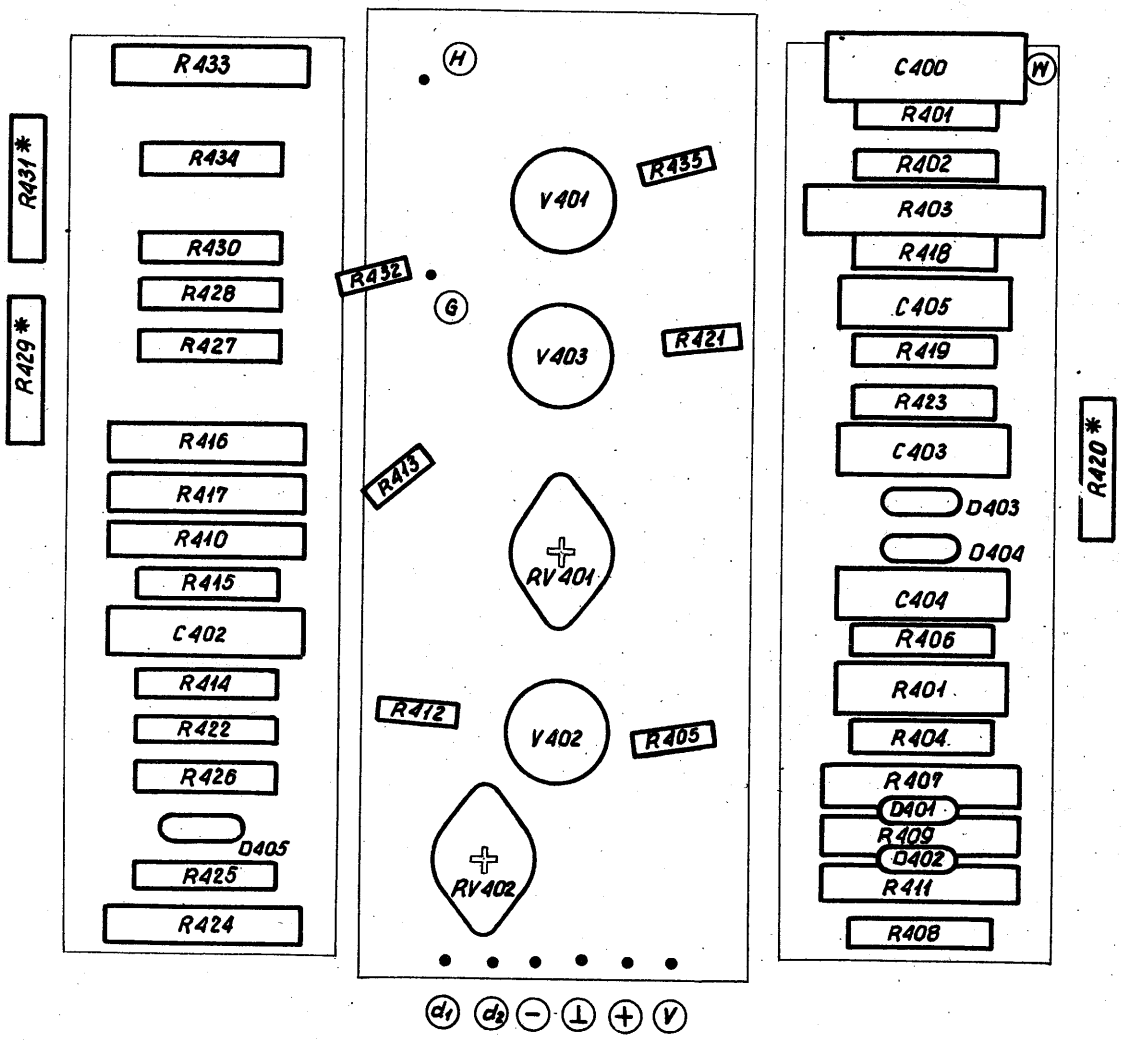

R433
R434
R430
R428
R427
R416
R417
R410
R415
C402
R414
R422
R426
D405
R425
R424
R431*
R429*
H
G
V401
V403
V402
RV401
RV402
R435
R432
R421
R413
R412
R405
C400
R401
R402
R403
R418
C405
R419
R423
C403
D403
D404
C404
R406
R401
R404
R407
D401
R409
D402
R411
R408
R420*
W
d1
d2
⊖
⊥
⊕
V

Fig.6.

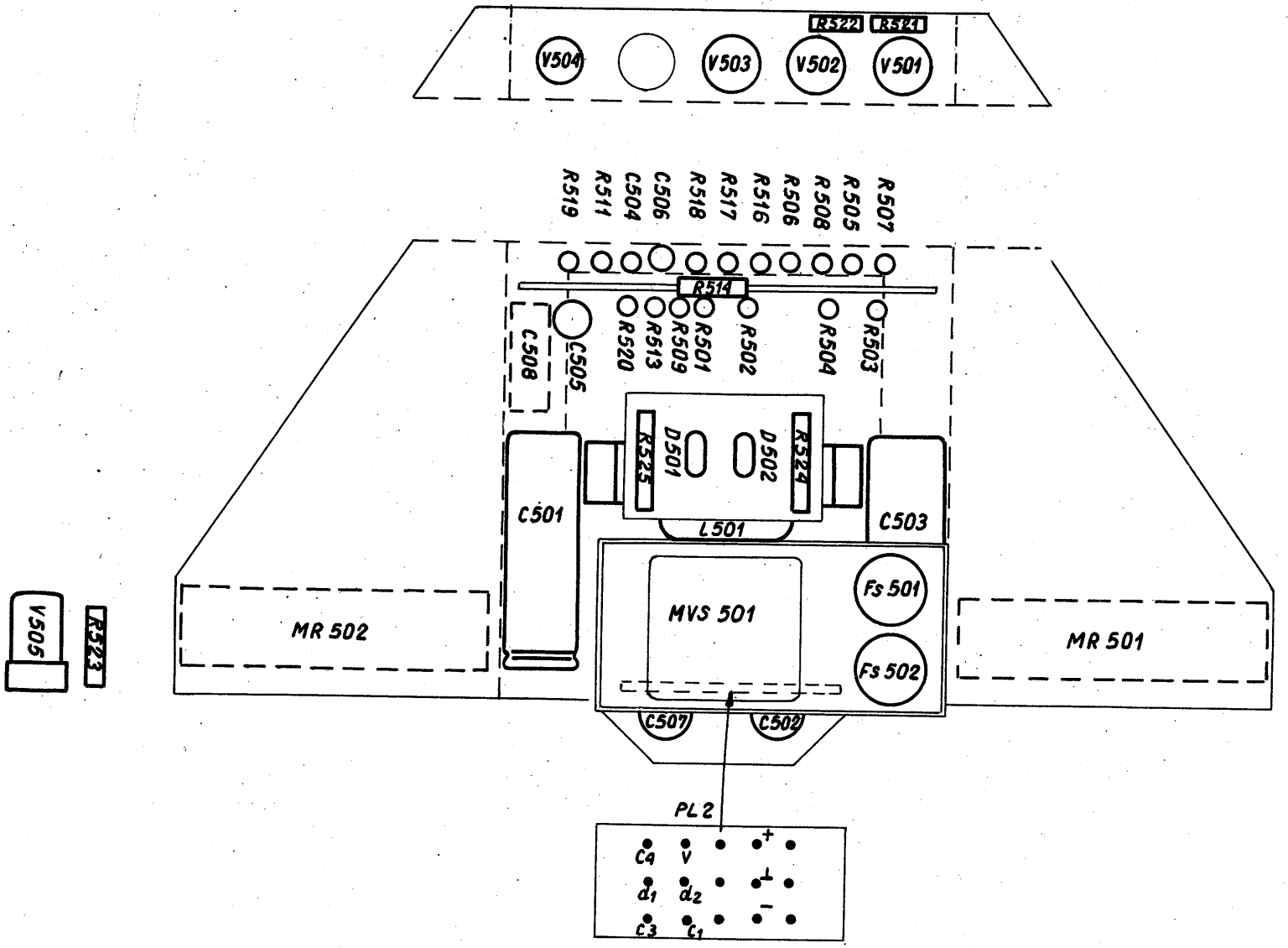

R522
R521
V504
V503
V502
V501
R519
R511
R504
C506
R518
R517
R516
R506
R508
R505
R507
R514
C508
C505
R520
R513
R509
R501
R502
R504
R503
R525
D501
D502
R524
C501
C503
L501
MR 502
MVS 501
Fs 501
Fs 502
MR 501
C507
C502
V505
R523
PL 2
C4
V
d1
d2
C3
C1
+
⊥
−

Fig.7.

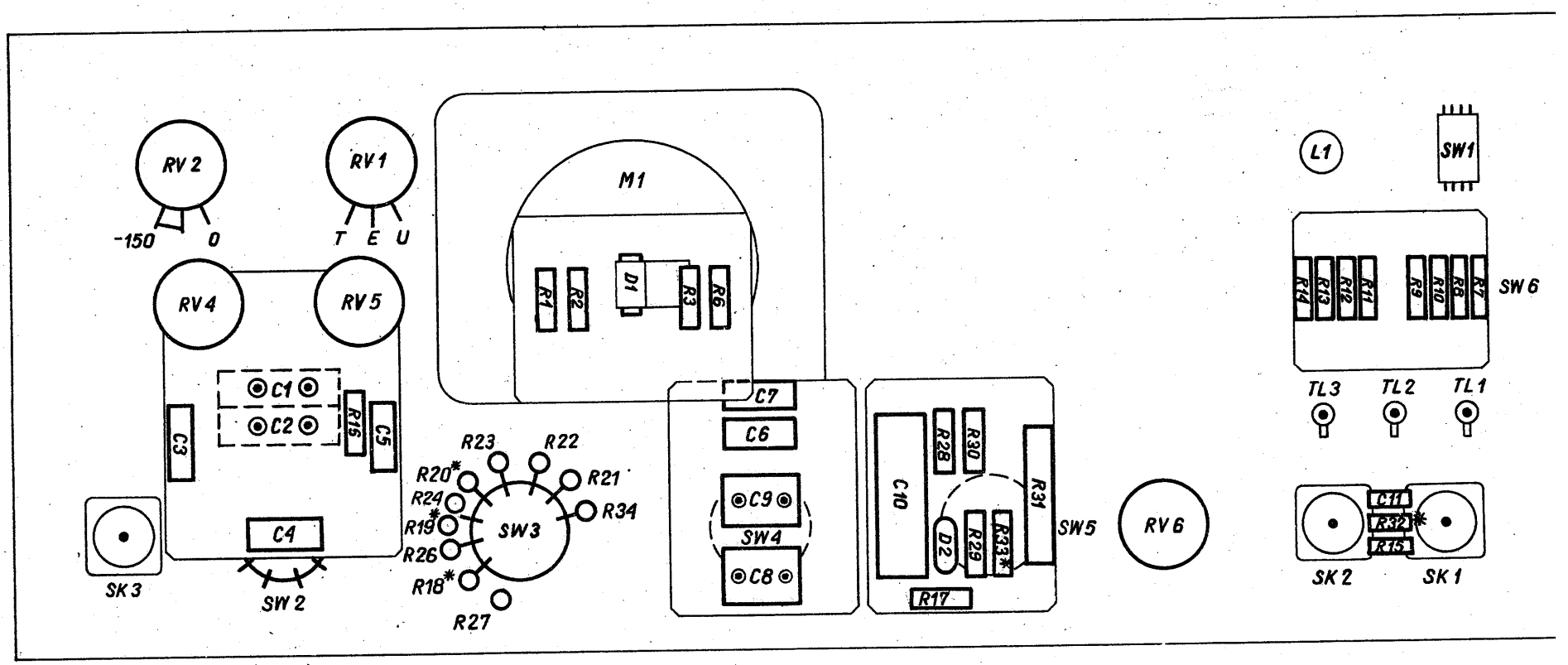

RV 2
-150
0
RV 1
T E U
M1
L1
SW1
RV 4
RV 5
R1
R2
D1
R3
R6
R14
R13
R12
R11
R9
R10
R8
R7
SW 6
C1
C2
R15
C3
C5
C7
C6
TL 3
TL 2
TL 1
R23
R22
R20*
R21
R24
R34
R19*
SW3
C9
SW4
C10
R28
R30
R31
SW5
RV 6
C11
R32*
R15
R26
R18*
C8
D2
R29
R33*
R17
SK 3
C4
SW 2
R27
SK 2
SK 1

Fig.8.

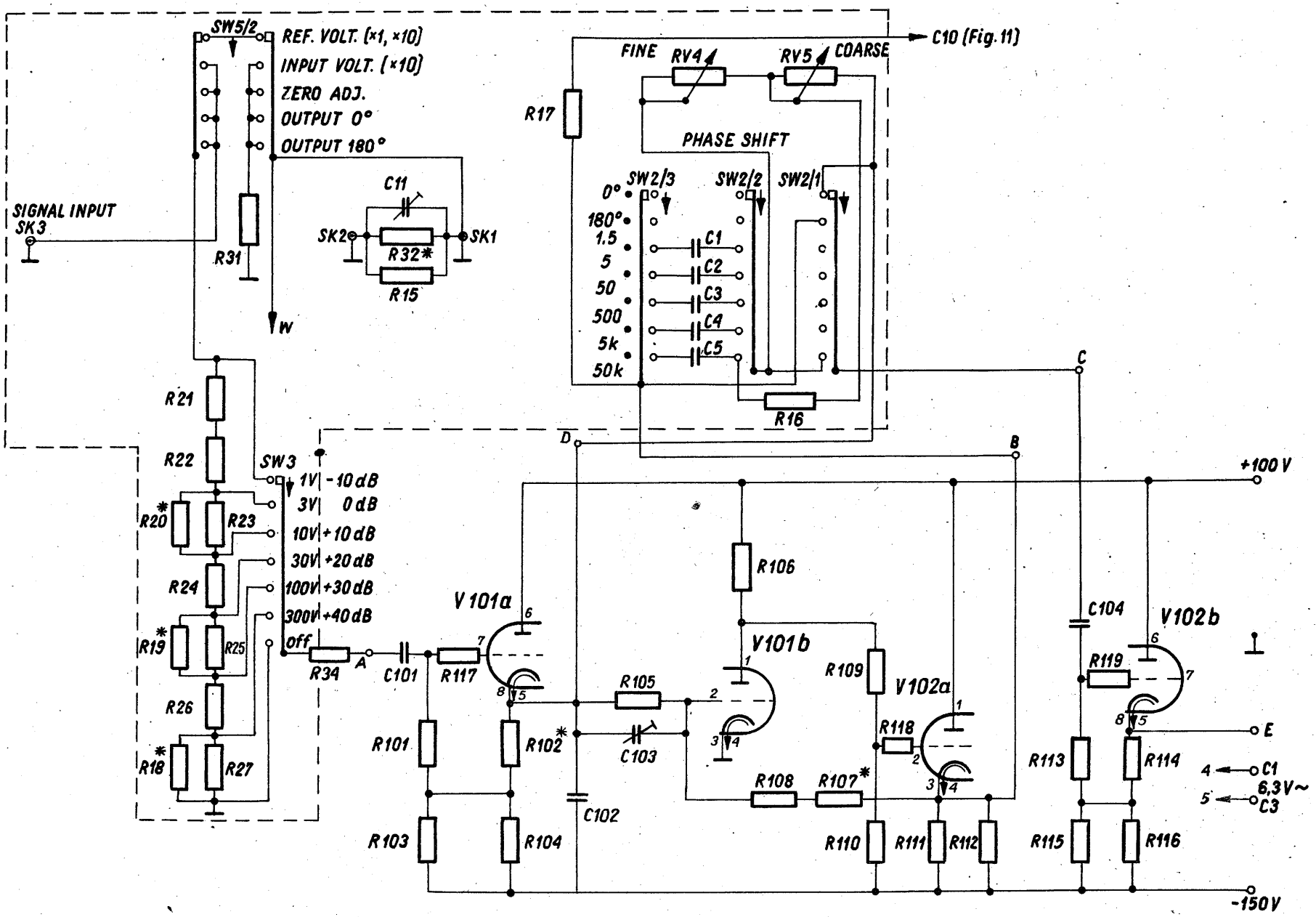

SW5/2
REF. VOLT. (×1, ×10)
INPUT VOLT. (×10)
ZERO ADJ.
OUTPUT 0°
OUTPUT 180°
SIGNAL INPUT
SK3
R31
C11
SK2
R32*
SK1
R15
C10 (Fig. 11)
FINE
RV4
RV5
COARSE
R17
PHASE SHIFT
0°
SW2/3
SW2/2
SW2/1
180°
1.5
5
50
500
5k
50k
C1
C2
C3
C4
C5
R16
C
D
B
R21
R22
SW3
1V
3V
10V
30V
100V
300V
off
-10dB
0dB
+10dB
+20dB
+30dB
+40dB
R20*
R23
R24
R19*
R25
R26
R18*
R27
R34
A
C101
R117
V101a
R106
V101b
R105
R109
V102a
R118
C103
R102*
R101
C102
R108
R107*
R103
R104
R110
R111
R112
C104
V102b
R119
R113
R114
R115
R116
+100V
E
C1
6,3V~
C3
-150V

Fig.9

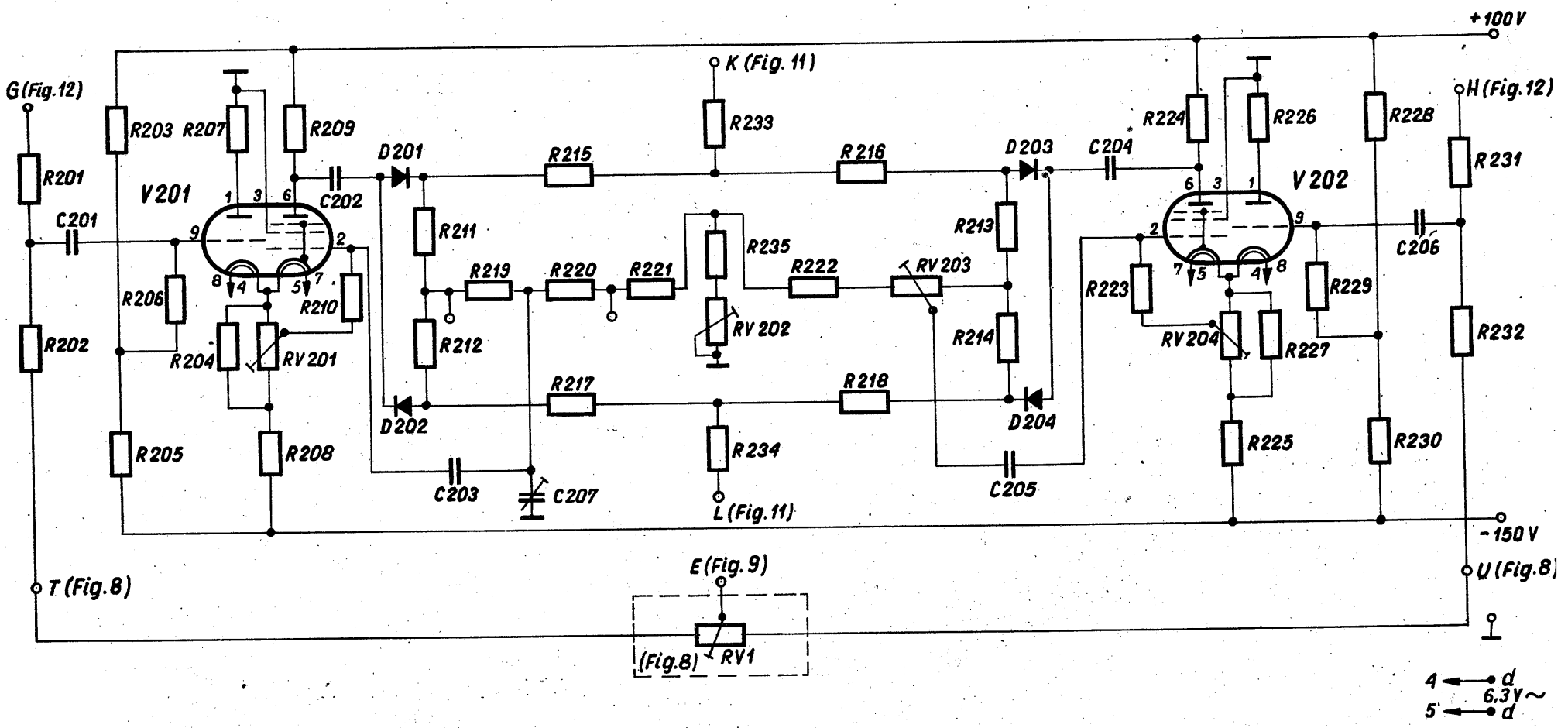

+100V
G (Fig.12)
K (Fig. 11)
H (Fig.12)
R201
R203
R207
R209
D201
R215
R233
R216
D203
C204
R224
R226
R228
R231
C201
V201
C202
V202
R211
R235
R213
R223
C206
R206
R219
R220
R221
R222
RV 203
R229
R210
RV 202
R214
RV 204
R232
R202
R204
RV 201
R212
R227
R217
R218
D204
D202
R205
R208
R234
R225
R230
C203
C207
C205
L (Fig.11)
-150V
T (Fig.8)
E (Fig.9)
U (Fig.8)
(Fig.8)
RV1
4
d
6.3V~
5
d

Fig.10.

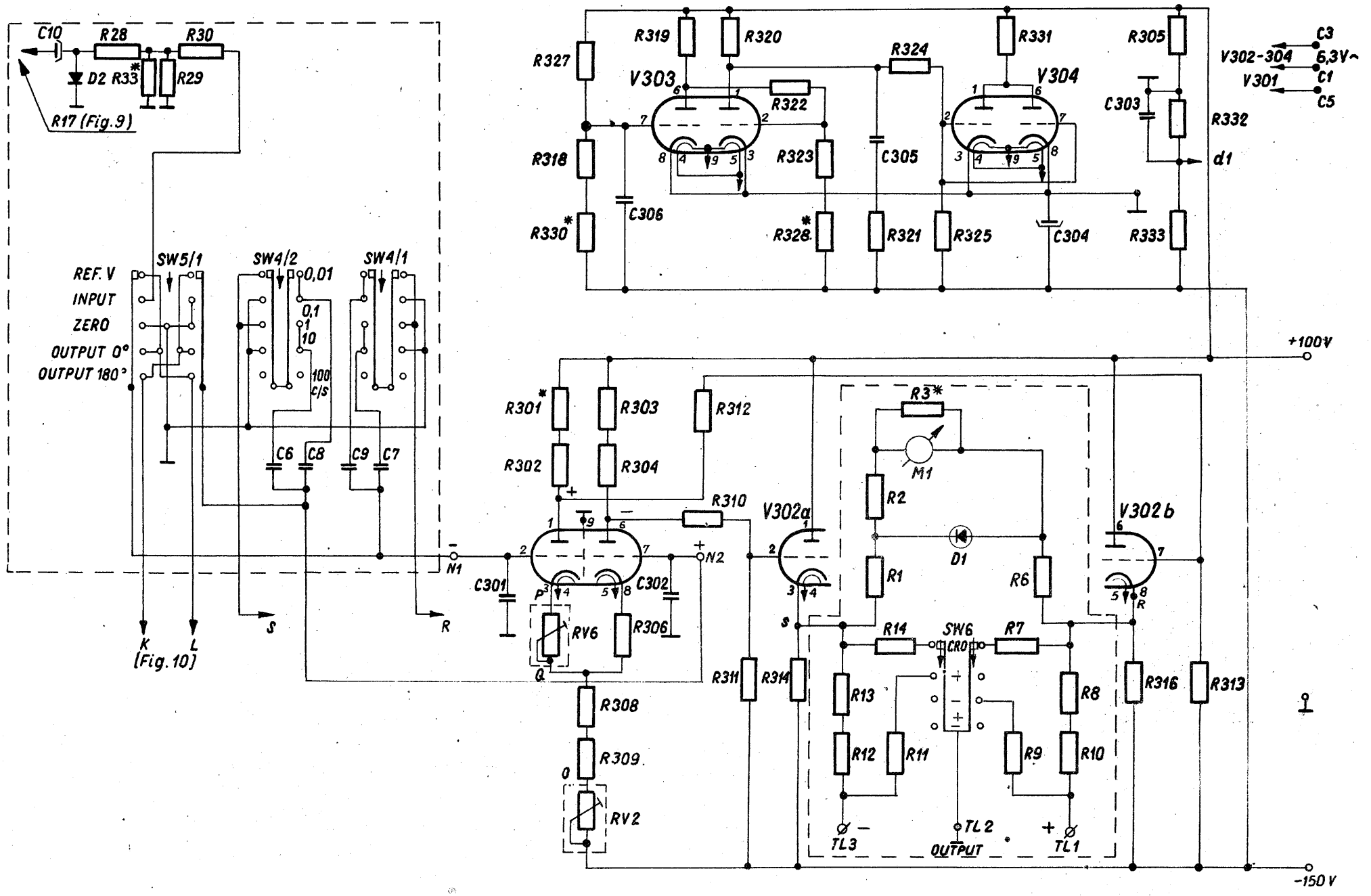

C10
R28
R30
D2
R33
R29
R17 (Fig.9)
REF. V
INPUT
ZERO
OUTPUT 0°
OUTPUT 180°
SW5/1
SW4/2
SW4/1
0,01
0,1
1
10
100 c/s
C6
C8
C9
C7
K
L
(Fig.10)
S
R
N1
N2
R319
R320
R327
V303
R322
R324
R331
V304
R305
C3
V302-304
6,3V~
V301
C1
C5
C303
R332
d1
R318
R323
C305
C306
R330*
R328*
R321
R325
C304
R333
+100V
R301*
R303
R312
R302
R304
R310
V302a
V302b
R3*
M1
R2
D1
R1
R6
C301
C302
RV6
R306
R14
SW6
CRO
R7
R311
R314
R316
R313
R13
R8
R12
R11
R9
R10
R308
R309
RV2
TL3
TL2
OUTPUT
TL1
-150 V

Fig.11.

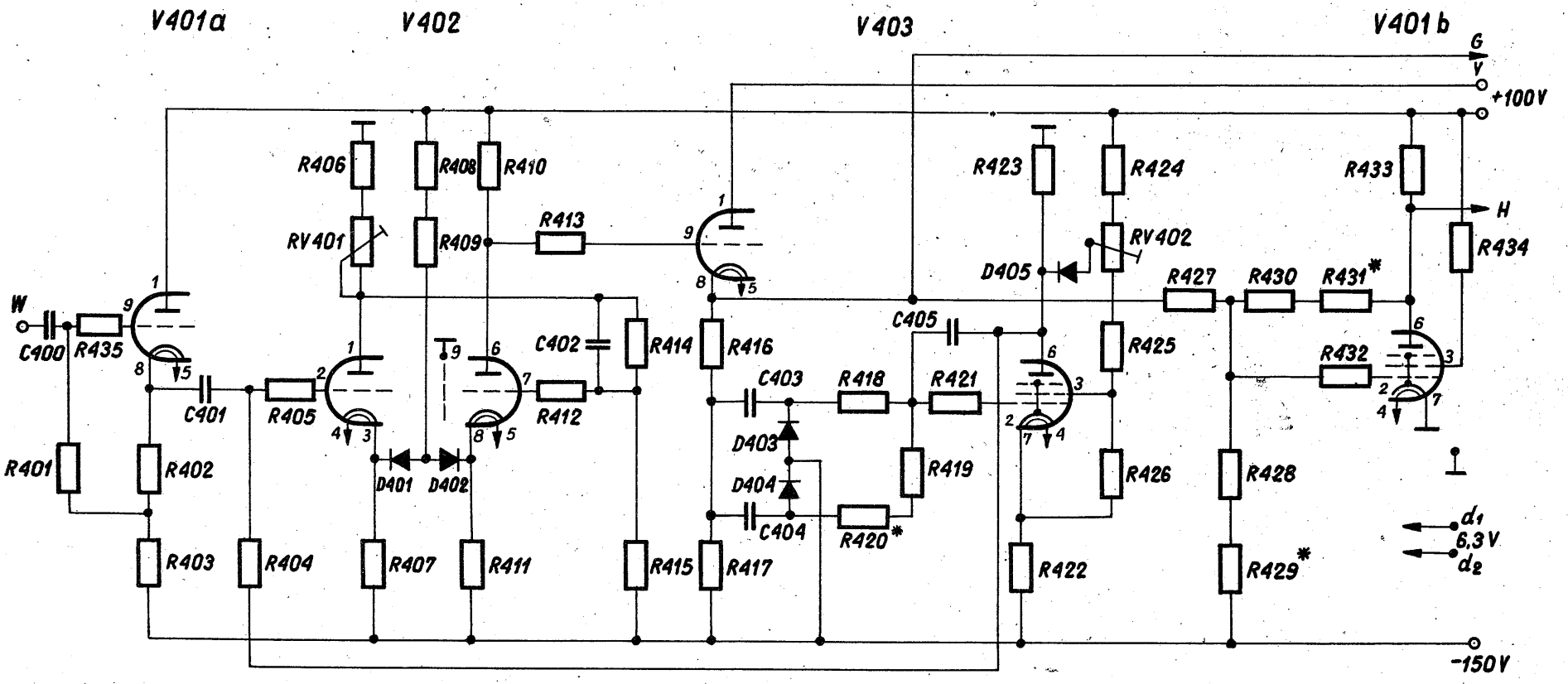

V401a
V402
V403
V401b
G
V
+100V
H
W
C400
R435
C401
R405
R406
R408
R410
RV401
R409
R413
C402
R414
R416
C403
R418
R421
C405
R423
R424
RV402
D405
R427
R430
R431*
R433
R434
R425
R432
R401
R402
R403
R404
D401
D402
R407
R411
D403
D404
C404
R420*
R419
R415
R417
R422
R426
R428
R429*
d1
6,3V
d2
-150V

Fig.12.

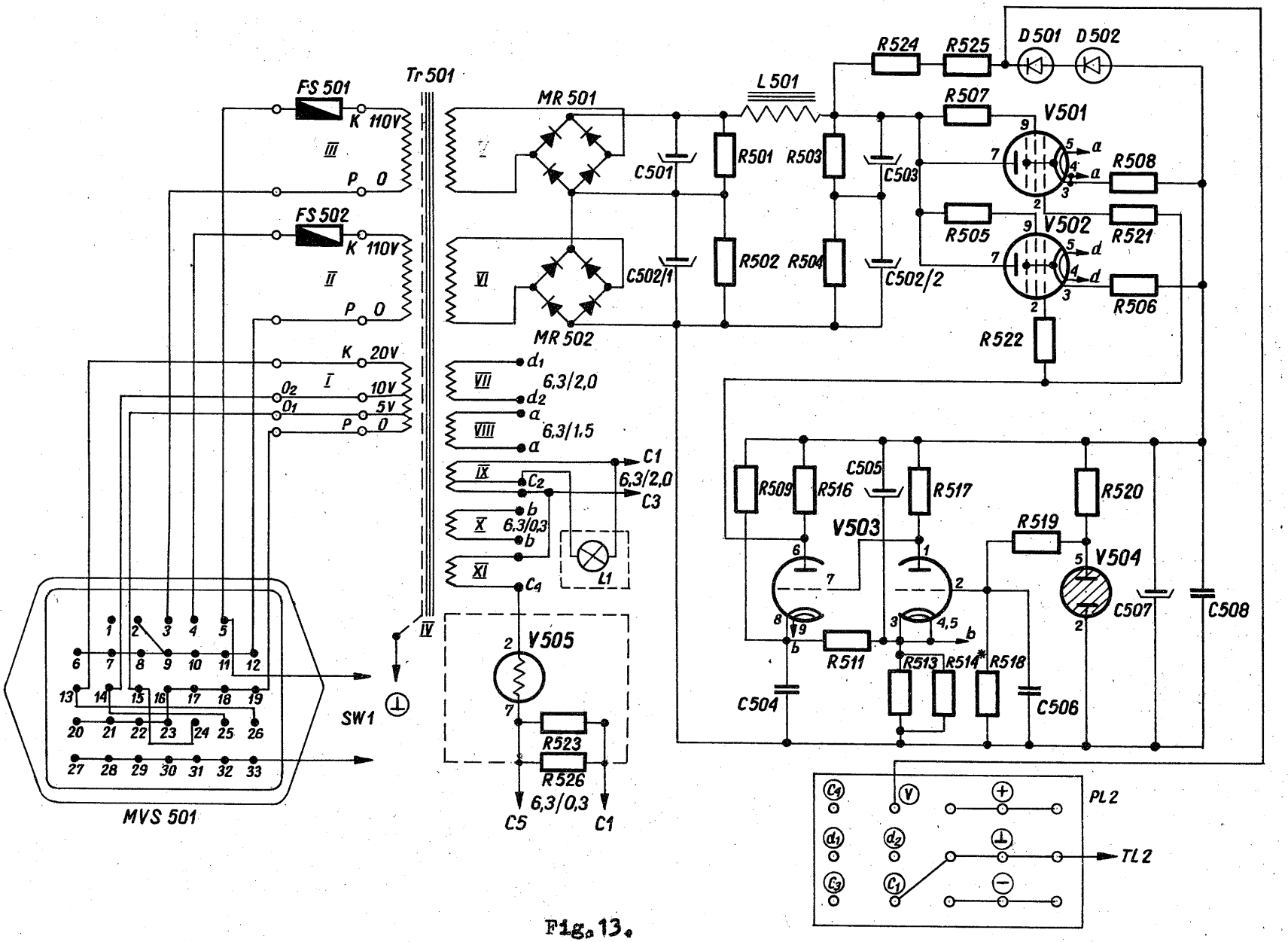
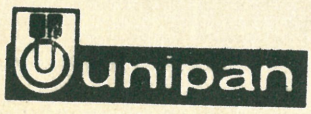

FS 501
K 110V
III
P O
FS 502
K 110V
II
P O
K 20V
I
O2 10V
O1 5V
P O
Tr 501
MR 501
MR 502
C501
C502/1
R501 R503
R502 R504
C503
C502/2
L 501
R524 R525
D 501 D 502
R507
V501
R508
R505
V502
R521
R506
R522
VII d1 6,3/2,0 d2
VIII a 6,3/1,5 a
IX C2 C1 6,3/2,0 C3
X b 6,3/0,3 b
XI C4
L1
IV
V505
R523
R526
6,3/0,3
C5 C1
SW1
MVS 501
R509 R516
C505
R517
R520
V503
R519
V504
C507
C508
R511
R513 R514* R518
C504
C506
PL 2
TL 2

Fig. 13.



ZAKŁAD DOŚWIADCZALNY BUDOWY APARATURY NAUKOWEJ
Przedsiębiorstwo Państwowe Podległe Polskiej Akademii Nauk